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ART. I.—*Contributions to Meteorology: being results derived from an examination of the Observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Ninth paper. With Plates I, II and III.

[Read before the National Academy of Sciences, Washington, April 19, 1878.]

Low barometer at Portland, Oregon.

IN my last paper, page 5, I showed that the great storms of the United States frequently come from British Columbia or its vicinity. In order to extend this part of the investigation I selected from the published volumes of the Signal Service observations (Sept., 1872, to Oct., 1874,) all those cases in which the barometer at Portland, Oregon, fell as low as 29·7 inches. These cases amount to sixty-three, and correspond to eighteen different storms, as is shown in the following table, in which column 1st shows the number of the storm; column 2d shows the date at which the barometer was below 29·7 inches; column 3d shows the height of the barometer at Portland at the date mentioned; column 4th shows the direction of the wind, and column 5th shows its velocity at Portland at the date mentioned; column 6th shows the rain-fall at Portland during the preceding eight hours; column 7th shows the least height of the barometer observed at that hour at any station within the same low area; column 8th shows the name of the station at which the barometer was lowest; column 9th indicates the region where the storm appears to have originated; Br. Co. denotes British Columbia; Can. denotes Canada, northwest;

Barometer below 29·7 inches at Portland, Oregon.

No.	Date.	Barom.	WIND. Direc.	WIND. Vel.	Rain. 8 hours.	Barom. lowest.	Station.	Originated where.	High on East side. Bar.	High on East side. Station.	Reached Atlc. Date.	Reached Atlc. Lat.
	1872.											
1	Nov. 7.3	29·68	S.	12	0·21	29·68	Portland, Or.	Br. Co.	30·18	Breckenridge	Nov.12	45°
2	Dec. 23.3	·57	N.E.	--	2·40	·57	Portland, Or.	Br. Co.	·95	Breckenridge	Dec. 31	42
	24.1	·15	S.E.	--	1·50	·15	Portland, Or.		·85	LaCrosse		
	24.2	·40	S.E.	4	·29	·37	Fort Benton		·64	Davenport		
	24.3	·62	S.E.	9	·05	·58	Virginia City		·64	Kingston		
	25.3	·64	N.E.	4	·32	·64	Portland, Or.		·77	Pembina		
	26.1	·65	E.	4	1·30	·65	Portland. Or.		·92	Breckenridge		
	1873.											
3	Jan. 4.2	·68	W.	3	·01	·68	Portland, Or.	Br. Co.	·41	Breckenridge	Jan. 11	48
4	Jan. 30.1	·64	S.E.	4	·23	·54	Virginia City	Br. Co.	·32	Pittsburgh	Feb. 5	45
	30.2	·55	S.	3	·06	·55	Portland, Or.		·23	Philadelphia		
	30.3	·55	S.	4	·10	·55	Portland, Or.		·33	Fort Benton		
5	Mar.30.1	·70	S.E.	20	·40	·70	Portland, Or.	Br. Co.	·20	San Francisco	Apr. 3	48
	30.2	·69	S.W.	8	·23	·56	Fort Benton		·23	San Francisco		
6	April 2.1	·68	S.E.	3	·09	·33	Alpena	Br. Co.	·18	Eastport	Apr.10	42
	2.2	·49	S.E.	21	·24	·33	Fort Garry		·05	Punta Rassa		
	2.3	·67	S.	12	·21	·40	Virginia City		·08	Punta Rassa		
7	Ap. 20.3	·66	S.E.	2	0	·66	Portland, Or.	Br. Co.	·16	Galveston	Apr. 23	35
8	Dec. 5.2	·69	E.	10	0	·69	Portland, Or.	Pac. O.	·64	LaCrosse	Dec. 9	48
9	Dec. 15.1	·62	S.	4	·02	·62	Portland, Or.	Br. Co.	·47	Vicksburg	Dec. 20	45
	15.2	·67	S.	24	·02	·67	Portland, Or.		·39	Charleston		
	1874.											
10	Jan. 1.3	·70	S.	8	·29	·45	Fort Benton	Can.	·64	Sydney	Jan. 5	48
	2.1	·61	S.	16	·03	·26	Fort Garry		·56	Sydney		
	2.2	·63	S.E.	8	·03	·09	Fort Sully		·44	Sydney		
	2.3	·70	S.	8	·29	·16	Fort Sully		·36	New London		
11	Jan. 14.2	·67	Calm	0	0	·67	Portland, Or.	Br. Co.	·89	Breckenridge	Jan. 19	45
	14.3	·59	S.	2	0	·59	Portland, Or.		·87	Yankton		
	15.1	·50	S.W.	2	·24	·50	Portland, Or.		·70	Yankton		
	15.2	·37	Calm	0	·11	·37	Portland, Or.		·57	LaCrosse		
	15.3	·23	Calm	0	·12	·23	Portland, Or.		·58	Davenport		
	16.1	·11	S.	6	·56	·11	Portland, Or.		·49	Louisville		
	16.2	·06	S.	30	·24	·06	Portland, Or.		·44	Cincinnati		
	16.3	·52	S.	7	·06	·14	Fort Benton		·47	Pittsburgh		
	17.1	·53	S.	2	·01	·00	Fort Garry		·56	Washington		
	17.2	·51	S.	2	0	·25	Fort Garry		·56	Philadelphia		
	17.3	·58	S.	4	0	·33	Fort Sully		·60	Philadelphia		
	18.1	·47	S.	28	0	·42	Virginia City		·62	Philadelphia	Jan. 23	46
	18.2	·60	S.W.	8	1·09	·45	Virginia City		·55	New London		
	18.3	·67	S.E.	4	·28	·67	Portland, Or.		·47	Boston		
	19.1	·56	S.	12	·22	·56	Portland, Or.		·49	Pembina		
	19.2	·65	S.W.	8	0	·63	Virginia City		·40	Marquette		
12	Feb. 10.3	·67	S.	8	0	·63	Virginia City	Br. Co.	·27	Mobile	Feb. 14	50
	11.3	·63	Calm	0	·10	·17	Fort Garry		·15	Punta Rassa		
	12.1	·60	Calm	0	0	·15	Leavenworth		·24	Brockville		
	12.2	·57	S.E.	12	·51	·08	Dubuque		·24	New London		
	12.3	·44	S.E.	5	·16	·35	Virginia City			?	Feb. 16	47
	13.1	·42	S.	13	·42	·39	Virginia City			?		
	13.2	·49	S.	10	·06	·41	Virginia City			?		
	13.3	·67	N.W.	8	·31	·47	Virginia City		·18	Cairo		
13	Feb. 28.2	·67	S.	16	0	·67	Portland, Or.	Br. Co.	·28	Norfolk	Mar. 4	46
14	Mar. 2.3	·47	S.W.	20	1·15	·47	Portland, Or.	Br. Co.	·36	Sydney	Mar. 8	47
	3.1	·61	S.	16	0	·29	Leavenworth		·34	Sydney		
15	Mar. 7.1	·55	S.	12	·56	·55	Portland, Or.	Br. Co.	·23	Fort Sully	Mar.11	30
	7.2	·60	S.	10	·06	·60	Portland, Or.		·28	Yankton		
	7.3	·67	S.	12	·06	·67	Portland, Or.		·45	Yankton		
16	Mar.12.2	·64	S.	13	0	·64	Portland, Or.	Br. Co.	·44	Breckenridge	Mar.20	48
	12.3	·70	S.W.	8	·07	·61	Virginia City		·45	Breckenridge		
	14.1	·66	S.	8	·15	·66	Portland, Or.		·45	Escanaba		
	15.2	·50	S.	8	·14	·40	Fort Sully		·42	Kingston		
	15.3	·58	S.	2	·03	·40	Virginia City		·43	Burlington		
	16.1	·69	Calm	0	0	·26	Fort Sully		·51	New London		
17	Ap. 12.1	·64	S.	3	·08	·49	Fort Sully	Pac. O.	·66	Alpena	Apr.16	48
18	Ap. 30.1	·63	S.	4	·25	·52	Fort Sully	Br. Co.	·37	Montgomery	May 4	35
	30.2	·66	S.	9	·33	·13	Fort Sully		·22	Mobile		

and Pac. O. denotes Pacific Ocean; column 10th shows the highest pressure observed at any station at the date mentioned in column 2d; and column 11th indicates the station at which this pressure was observed. Each of these areas of low pressure appears to have moved eastward, and can be traced to the Atlantic coast. Column 12th shows the date at which the center of low pressure reached the Atlantic coast, and column 13th shows the latitude of the low center at that time.

A comparison of these cases shows that they all occurred during the six colder months of the year, and they were most numerous in January. In a majority of the cases the wind blew from the south, and in only three cases did the wind blow from any northern quarter. The greatest force of the wind in any case was thirty miles per hour; in six cases it rose as high as twenty miles per hour, and the average velocity was 8·2 miles per hour.

In forty-six per cent of the cases, the pressure at Portland was lower than at any other station at the same hour; in twenty-seven per cent of the cases, the lowest pressure was at Virginia City or Fort Benton; in thirteen per cent of the cases, the lowest pressure was at Fort Sully; and in the remaining cases the lowest pressure was at some station still further east. A comparison of the observations at Virginia City with those at neighboring stations indicates that the readings of the barometer at Virginia City are too low, and accordingly they have all been increased by 0·26 inch.

With but two exceptions, all of these cases of low pressure appear to have originated north of Portland, and generally west of that station. In the table, this region is designated by the term British Columbia. It is probable that in some of these cases, and perhaps in all of them, the area of low pressure was first formed over the Pacific Ocean. No. 10 was apparently formed on the east side of the Rocky Mountains, but north of the United States, a region designated as Canada N. W. Nos. 8 and 17 were apparently formed over the Pacific Ocean, near the latitude of San Francisco.

In a majority of these cases there was an area of high barometer on the east side of Portland, at an average distance of about 1500 miles. In one case the barometer rose to 30·95 inches; in six cases the barometer rose as high as 30·75 inches; in one-third of the cases the pressure rose to 30·5 inches; and in more than two-thirds of the cases the pressure rose to 30·25 inches. In five cases (out of sixty-three) there was no station within the limits of the United States where the pressure rose as high as 30·15 inches at the dates mentioned. No. 17 is represented on Plate III accompanying the present paper, and No. 2 is represented on Plate I accompanying my fifth paper.

In each case the center of low pressure traveled eastward, and can be traced to the Atlantic coast. No. 11, being a depressed period of five days' continuance, should probably be regarded as consisting of two depressed areas, the second of which immediately succeeded the first, so that the two were united in Oregon, but traveled across the continent independently, one of them reaching the Atlantic four days later than the other. So also No. 12 apparently consisted of two depressed areas which were united in Oregon, but traveled across the continent independently, one of them two days later than the other. The average time of crossing the continent was five days, and the average latitude where the low center met the Atlantic was 45°.

The paths by which these areas of low pressure crossed the continent differed considerably from arcs of great circles. Starting from the Pacific Ocean, generally as far north as latitude 50°, the course was toward the southeast, until near the middle of the continent, and on the meridian of 100° from Greenwich the average latitude of the paths was 40°. Thence the course gradually veered northward, and upon reaching the Atlantic the average latitude of the paths was 45°.

Low barometer at San Francisco, California.

The observations made at San Francisco have been discussed in the same manner as those at Portland. The following table shows all the cases in which (during a period of twenty-six months) the barometer fell as low as 29·7 inches. The table is constructed in the same manner as that for Portland.

The number of these cases is twenty-nine, corresponding to nine different storms, and most of them occurred during the winter months. A single case is reported for the summer months, which apparently resulted from causes operating over the central portion of the North American continent. In three-fourths of the cases the wind blew from some southern quarter, and in only three cases did it blow from a northern quarter. The average velocity of the wind was fifty per cent greater than at Portland, a result which may be ascribed to greater proximity to the ocean.

In more than one-third of the cases the pressure at San Francisco was the lowest reported at any station at the same hour. In eleven of the cases the greatest depression was on the east side of the Rocky Mountains, and in eight cases the point of greatest depression was situated about 1400 miles eastward. Five of these depressions appear to have originated over the Pacific Ocean; the remaining four appear to have originated north of the United States, two of them on the west side of the Rocky Mountains and two on the east side.

Barometer below 29·7 inches at San Francisco.

No.	Date.	Barom.	WIND. Direc.	WIND. Vel.	Rain. 8 hours.	Barom. lowest.	Station.	Originated where.	High on East side. Bar.	High on East side. Station.	Reached At'lc. Date.	Reached At'lc. Lat.
	1872.											
1	Dec. 28.2	29·68	S.E.	14	0·11	29·68	San Francisco	Pac. O.	30·47	Nashville	Dec. 31	43°
	1873.											
2	Jan. 31.2	·55	S.E.	20	·04	·55	San Francisco	Pac. O.	·78	Breckenridge	Feb. 5	45
	31.3	·60	S.W.	4	·28	·60	San Francisco		·85	Breckenridge		
	Feb. 1.1	·65	N.E.	4	0	·65	San Francisco		·95	Fort Sully		
	1.2	·64	N.	4	0	·64	San Francisco		·82	Leavenworth		
	1.3	·67	S.	8	·02	·67	San Francisco		·74	Davenport		
3	Feb. 24.1	·61	W.	8	·05	·49	Corinne	Pac. O.	·35	Fort Sully	Feb. 28	43
	24.2	·60	W.	16	0	·41	Corinne		·28	Fort Sully		
	24.3	·64	W.	12	0	·38	Corinne		·36	Fort Sully		
4	July 1.3	·70	S.W.	12	0	·59	Fort Garry	Can.	·18	Lake City	July 6	45
5	Sep. 25.3	·68	S.W.	8	0	·14	Fort Sully	Can.	·13	Halifax	?	50+
	26.1	·66	S.W.	12	0	·25	Breckenridge		·21	Washington		
	26.2	·66	S.W.	16	0	·20	Fort Garry		·22	Cape May		
	26.3	·68	S.W.	12	0	·53	Fort Garry		·26	Philadelphia		
6	Dec. 3.3	·67	S.E.	20	·76	·66	Cheyenne	Pac. O.	·28	Charleston	Dec. 9	48
	4.1	·63	N.W.	16	·72	·63	San Francisco		·42	St. Louis		
	4.2	·57	S.	20	·08	·57	San Francisco		·39	Cairo		
	4.3	·55	S.	20	·05	·55	San Francisco		·55	Fort Sully		
	5.1	·62	S.	8	·99	·62	San Francisco		·65	Fort Sully		
	7.1	·70	S.E.	8	·25	·61	Corinne		·71	Kingston		
	7.3	·67	S.E.	4	·07	·66	Cheyenne		·71	Montreal		
	8.1	·69	Calm	0	0	·69	San Francisco		·76	Chatham		
	1874.											
7	Jan. 15.3	·55	S.	28	·31	·23	Portland, Or.	Br.Col.	·58	Davenport	Jan. 19	45
	16.1	·58	S.W.	24	·22	·11	Portland, Or.		·49	Louisville		
	16.3	·67	S.W.	8	0	·14	Fort Benton		·47	Pittsburgh		
	17.1	·56	S.	24	·41	·00	Fort Garry		·56	Lynchburg		
	17.2	·63	S.W.	16	·35	·25	Fort Garry		·56	Philadelphia		
8	Feb. 12.1	·70	S.W.	12	·07	·15	Leavenworth	Br.Col.	·24	Brockville	Feb. 14	50
9	Apr. 11.1	·70	W.	16	0	·62	Salt Lake City	Pac. O.	·45	Pembina	Ap. 16	48

In nearly all of these cases there was an area of high barometer on the east side of San Francisco at an average distance of 1500 miles. In one case the barometer rose to 30·95 inches, and in two-thirds of the cases it was as high as 30·36 inches. In No. 4 a moderate depression of the barometer extended over the entire United States, with the exception of the southeast portion. This low area continued to cover a considerable part of the United States without much change during a period of fifteen days.

In each of these cases (with perhaps a single exception) the center of low pressure traveled eastward across the Rocky Mountains, and can generally be traced entirely across the continent, although in some cases the barometric wave experienced considerable modification in its progress. On account of the uncertainty attending the reduction of the mountain observations to the level of the sea, the progress of the barometric wave is best exhibited by the *changes* of pressure, without regard to

the absolute height of the barometer. Plate I exhibits the oscillations of the barometer for Nos. 2, 3 and 9 at San Francisco and several other stations, extending eastward to the Valley of the Mississippi, and a change of pressure of one-tenth of an inch is represented by one-tenth of an inch in the diagram. Plate II represents three other cases in which the minimum of pressure is pretty sharply defined, and the progress of the barometric wave is very distinctly indicated. These examples show conclusively that barometric waves sometimes travel from the Pacific coast across the Rocky Mountains into the Valley of the Mississippi, with so little change as to leave no doubt of their identity. It will be noticed, however, that the barometric oscillation generally increases quite rapidly as soon as the wave reaches the Mississippi Valley; and in several of the diagrams palpable changes will be perceived in the form of the curves from one station to another. In several of the cases, not here represented, these changes are still more considerable.

The minimum at Salt Lake City usually occurs about sixteen hours later than at San Francisco, and at Cheyenne about one day later than at San Francisco. This indicates a velocity of forty miles per hour, which is greater than the velocity usually found for barometric waves; but it is probable that the motion of the center of low pressure was not parallel to the line joining San Francisco and Cheyenne, so that the velocity of the center of low pressure was less than forty miles per hour. It seems, then, to be clearly established that barometric waves frequently travel from the Pacific coast across the Rocky Mountains and reach the Mississippi Valley with but little modification. The Rocky Mountains form an uninterrupted barrier 6,000 feet in height from British America southward to latitude 32°, and the Sierra Nevadas present a barrier of the same height extending from British America southward to latitude 36°, with but three interruptions amounting in the aggregate to less than one hundred miles. The Rocky Mountains form a barrier of 10,000 feet in height, which extends nearly half the distance from latitude 49° to latitude 32°, and which is continuous for about 350 miles in the neighborhood of Colorado. The Sierra Nevadas also present short ranges of equal altitude, but the longest of them is less than 150 miles.

Thus we see that an unbroken mountain range of 6,000 feet in height cannot stop the progress of atmospheric waves; neither do ranges of more than 10,000 feet in height, broken as in North America, present any insuperable obstacle. A great barometric depression requires either a wind blowing with a hurricane velocity, or else a system of converging winds extending over a vast area. The mountain ranges between the Pacific Ocean and the Mississippi Valley present obstructions to the formation

of a system of winds of very great geographical extent, and this is probably one reason why the barometric fluctuations at the mountain stations are less than they are in the Mississippi Valley. The oscillations of the barometer are generally somewhat greater at Salt Lake City than at San Francisco, and generally they become very much magnified after crossing the Rocky Mountains. The depression of the barometer at the center of a great storm is mainly due to the geographical extent of the system of winds set in motion; and after a storm-center has reached the Mississippi River, there are no mountain barriers to prevent the formation of a system of circulating winds over an area 2,000 miles in diameter.

Areas of high barometer.

Each of the areas of low barometer described in my eighth paper was preceded by an area of high barometer on the east side at an average distance of about 1,000 miles, and was followed by an area of high barometer on the west side at about the same distance.

In order to discover the circumstances under which areas of high barometer originate, and the relations which they bear to areas of low barometer, I selected from the published volumes of the Signal Service observations all those cases in which the barometer at any station rose above 30·65 inches. Sometimes at the same hour the barometer was above 30·65 inches at a considerable number of stations, all included within the same high area. In such cases, only one of the stations was employed, viz., the station at which the barometer was highest. These cases of high barometer are exhibited in the following table, in which column 1st shows the number of the high area; column 2d shows the date at which the barometer was above 30·65 inches; column 3d shows the greatest height of the barometer observed at that hour; column 4th shows the name of the station at which the given height was observed; column 5th shows the temperature at the given station at the given hour; column 6th shows the highest velocity of the wind which preceded each of these areas of high barometer; column 7th indicates the region where this high area appears to have originated; the abbreviations are the same as in the preceding tables, except Ark. which denotes Arkansas; column 9th shows the station where the barometer was lowest on the east side of the high area; column 8th shows the height of the barometer at the given station; column 11th shows the station where the barometer was lowest on the west side of the high area; and column 10th shows the height of the barometer at the given station.

Barometer above 30·65 inches.

No.	Date.	Barom.	Station.	Therm.	Wind preceding.	Originated where.	Low on East side. Bar.	Low on East side. Station.	Low on West side. Bar.	Low on West side. Station.
	1872.			°						
1	Oct. 29.1	30·66	Kingston	33	33	Can.			29·69	Omaha.
2	Nov 13.3	·79	Fort Benton	13	47	Br.Col.	29·55	St. Paul		
	14.1	·87	do.	11			·63	Marquette		
	14.2	·88	do.	18			·65	Escanaba		
	14.3	·88	do.	0			·51	Montreal		
	15.1	·81	do.	−13			·30	Quebec		
	15.2	·67	do.	14			·59	Quebec		
	16.3	·69	do.	3			·96	Quebec		
	17.1	·75	Nashville	19						
	17.3	·71	Leavenworth	14						
3	Nov 18.2	·67	Portland, Or.	43	32	Br.Col.	·90	Fort Sully		
4	Nov 28.1	·71	Breckenridge	−12	57	Br.Col.	·91	Quebec		
	28.2	·84	do.	− 6			·98	Buffalo		
	28.3	·98	Duluth	0			·78	Rochester	·99	Portland, Or.
	29.1	·93	Breckenridge	−15			·74	Boston	·95	Portland, Or.
	29.2	·71	Memphis	26			·55	Boston	·95	Portland, Or.
5	Dec. 8.2	·70	Breckenridge	− 3	41	Br.Col.	·47	Montreal		
	8.3	·78	do.	−11			·45	Rochester		
	9.1	·82	do.	−14			·42	Montreal		
6	Dec. 21.1	·72	Leavenworth	− 2	38	Br.Col.	·69	Halifax		
	21.2	·71	do.	0			·80	Halifax	·73	Fort Benton.
	21.3	·72	Nashville	10			·88	Oswego	·68	Virginia City.
7	Dec. 23.1	·70	Breckenridge	−33	40	Can.	·71	Alpena	·79	Cheyenne.
	23.2	·88	do.	−24			·74	Montreal	·74	do.
	23.3	·95	do.	−31			·63	Halifax	·57	Portland, Or.
	24.1	·85	La Crosse	−27			·82	do.	·15	do.
	25.1	·66	Kingston	−21					·68	Cheyenne.
8	Dec. 25.3	·77	Pembina	−24	32	Can.	·72	Wilmington	·64	Portland, Or.
	26.1	·92	Breckenridge	−27			·46	Norfolk	·65	do.
	26.2	·92	do.	−22			·51	New London	·76	do.
	26.3	·84	do.	−27			·31	Halifax	·93	do.
	27.1	·88	do.	−33			·17	do.	·83	Cheyenne.
	1873.									
9	Jan. 12.1	·66	Charleston	36	36	Arkan.			·51	Fort Sully.
10	Jan. 15.1	·81	Portland, Me.	3	40	Can.			·59	Leavenworth.
	15.2	·82	do.	12					·60	Milwaukee.
	15.3	·82	Halifax	10					·67	Alpena.
11	Jan. 16.1	·72	Breckenridge	−26	38	Br.Col.	·59	Louisville		
	16.2	·68	do.	−15			·45	Buffalo		
	16.3	·79	do.	−22			·36	Quebec		
	17.1	·77	do.	−19			·54	Quebec		
	17.3	·66	St. Paul	−15			·80	Wilmington	·95	Fort Benton.
	18.1	·67	La Crosse	−36			·74	Philadelphia	·90	Fort Benton.
12	Jan. 27.2	·75	Breckenridge	−17	40	Br.Col.	·59	New London	·38	Santa Fe.
	27.3	·92	do.	−29			·17	Halifax	·65	Santa Fe.
	28.1	·85	do.	−35			·37	do.	·82	Santa Fe.
	28.2	·74	Leavenworth	− 3			·76	do.	·78	Santa Fe.
	28.3	·72	do.	−12			·71	do.	·71	Fort Benton.
13	Jan. 31.1	·66	Breckenridge	−17	34	Can.	·82	Quebec	·65	Corinne.
	31.2	·78	do.	−19			·82	Halifax	·55	S. Francisco.
	31.3	·85	do.	−25			·89	Quebec	·48	do.
	Feb. 1.1	·95	Fort Sully	−20			·97	Halifax	·65	S. Francisco.
	1.2	·82	Leavenworth	4			·92	do.	·64	do.
	1.3	·74	Davenport	2			·87	do.	·67	do.

Barometer above 30·65 inches.

No.	Date.	Barom.	Station.	Therm.	Wind preceding.	Originated where.	Low on East side. Bar.	Low on East side. Station.	Low on West side. Bar.	Low on West side. Station.
	1873.			°						
	Mar. 1.3	30·77	Fort Sully	6	36	Can.	29·98	Quebec		
	2.1	·93	do.	6			·94	do.		
	2.2	·84	do.	8			·70	do.		
	2.3	·86	Breckenridge	−22			·82	Cape May		
	3.1	·88	do.	−31			·58	New London		
	3.2	·75	St. Paul	7			·35	Portland, Me.		
	3.3	·97	do.	− 1			·36	do.	29·97	Portland, Or.
	4.1	·91	Omaha	9			·64	do.	·87	do.
14	4.2	·70	Chicago	20			·88	do.	·76	do.
	4.3	·73	do.	11					·75	do.
	5.1	·78	Knoxville	11					·70	Fort Benton.
	5.2	·69	Port Stanley	20					·55	do.
	5.3	·72	Baltimore	23					·52	do.
	6.1	·78	Lynchburg	14					·45	do.
	6.2	·69	Norfolk	36					·35	Fort Sully.
	6.3	·71	Augusta	37					·42	do.
	7.1	·67	do.	30					·42	Duluth.
15	Mar. 24.3	·68	Fort Sully	1	30	Br.Col.	·63	Cairo		
	25.1	·76	do.	− 5			·64	Nashville	·94	Portland, Or.
	Nov 29.1	·66	Pembina	−12	32	Can.	·74	Cape Rosier	·80	Portland, Or.
	29.2	·67	do.	− 1			·85	do.	·75	do.
	29.3	·72	do.	− 4			·90	do.	·77	do.
	30.1	·70	Kingston	8					·84	do.
	30.2	·73	do.	6					·74	Virginia City.
	30.3	·77	do.	5					·66	do.
16	Dec. 1.1	·80	Quebec	−12					·71	Cheyenne.
	1.2	·78	Montreal	0					·64	do.
	1.3	·77	Father Point	− 2					·62	do.
	2.1	·84	Chatham	−16					·56	do.
	2.2	·79	do.	1					·47	do.
	2.3	·71	Halifax	19					·52	Dubuque.
	3.1	·67	Sydney	20					·54	Escanaba.
	Dec. 5.3	·73	LaCrosse	2	49	Can.			·73	Portland, Or.
	6.1	·71	Toledo	23					·76	do.
17	7.1	·71	Kingston	20					·61	Corinne.
	7.3	·71	Montreal	20					·66	Cheyenne.
	8.1	·76	Chatham	6					·77	Breckenridge.
18	Dec. 9.1	·67	Yankton	5	54	Can.	·76	Father Point		
19	Dec. 19.3	·67	do.	0	31	Br.Col.	·65	Boston		
	20.1	·68	do.	− 8			·58	Halifax		
20	Dec. 30.1	·66	Fort Gibson	16	32	Can.	·33	Cape Rosier		
	1874.									
	Jan. 5.3	·74	Father Point	15	32	Br.Col.			·68	Fort Garry.
21	6.1	·93	Chatham	6					·85	Fort Garry.
	6.2	·79	Cape Rosier	10					·74	Augusta, Ga.
	6.3	·67	Chatham	18					·61	do.
	Jan. 13.1	·87	Fort Sully	− 7	43	Can.			·92	San Diego.
	13.2	·81	Breckenridge	− 4					·92	do.
	13.3	·89	Yankton	− 8			·92	Cleveland	·96	do.
22	14.1	·96	do.	−11			·79	New London	·80	Portland, Or.
	14.2	·89	Breckenridge	−23			·47	Eastport	·67	do.
	14.3	·87	Yankton	−10			·28	Halifax	·59	do.
	15.1	·70	do.	− 7			·19	do.	·50	do.
23	Jan. 20.3	·69	Father Point	3	40	Can.			·60	Cheyenne.
	21.1	·74	Chatham	− 7					·38	Fort Gibson.

Barometer above 30·65 inches.

No.	Date.	Barom.	Station.	Therm.	Wind preceding.	Originated where.	Low on East side.		Low on West side.	
							Bar.	Station.	Bar.	Station.
	1874.			°						
24	Jan. 23.3	30·71	Yankton	− 2	38	Can.	29·27	Cape Rosier		
	24.1	·36	do.	−17			·77	do.		
	24.2	·90	Cairo	36						
	24.3	·91	do.	28						
	25.1	·91	LaCrosse	3			·85	Eastport	29·95	Portland, Or.
	25.2	·81	Milwaukee	11			·79	Halifax	·86	do.
	25.3	·75	Port Stanley	3			·88	do.	·83	Fort Benton.
	26.1	·81	Memphis	41			·76	Sydney	·80	do.
25	Jan. 29.2	·80	Pembina	−18	47	Br.Col.	·88	Cape Rosier		
	29.3	·98	do.	−26			·98	do.		
	30.1	·77	do.	−22			·73	Halifax		
	30.2	·67	do.	−10					·69	Santa Fe.
	30.3	·66	do.	−21					·65	do.
	31.1	·69	Chatham	−35					·60	do.
	31.3	·69	Marquette	2					·64	do.
	Feb. 1.1	·79	Brockville	−25					·74	do.
	1.2	·84	Burlington	− 6						
	1.3	·87	do.	−13						
	2.1	·89	Chatham	−22						
	2.2	·76	Father Point	− 6					·98	Mobile.
	2.3	·73	Halifax	−10						
26	Feb. 5.1	·66	Brockville	− 8	30	Br.Col.	·59	Sydney	·63	Santa Fe.
27	Feb. 23.2	·72	Yankton	11	50	Br.Col.	·56	Quebec		
	23.3	·86	do.	− 2			·47	Father Point		
	24.1	·82	do.	− 1			·63	Sydney		
	24.2	·71	LaCrosse	5						
	24.3	·68	do.	3						
28	Mar. 23.1	·73	Breckenridge	− 8	48	Br.Col.	·47	Sydney		
	23.2	·67	do.	15			·38	do.		
	23.3	·71	Davenport	21			·49	do.		
	24.1	·70	St. Louis	23			·60	do.		
29	Apr. 12.1	·66	Alpena	18	32	Can.	·49	do.	·49	Fort Sully.
30	Sep. 17.3	·67	Cape Rosier	39	35	Br.Col.			·58	Fort Garry.
	18.1	·70	do.	47					·69	Leavenworth.
	18.2	·66	do.	48					·49	do.
31	Oct. 12.1	·70	Yankton	16	37	Can.	·60	Cape Rosier	·95	S. Francisco.
32	Oct. 30.3	·70	Fort Sully	16	41	Br.Col.	·47	Sydney		

These cases correspond to thirty-two different areas of high barometer, and thirty of these occurred during the six months from October to March, and none occurred during the four months from May to August. More than half of the whole number occurred during the months of December and January. Areas of unusually high pressure are thus found to occur at the same season of the year as areas of unusually low pressure.

In order to show how far these cases of high pressure are dependent upon latitude and longitude, I have divided the stations into three classes; one class including the stations east of longitude 86° from Greenwich; a second class including the stations between the meridians of 86° and 102°; the third class including the stations west of the meridian of 102°.

Classification of the cases of high pressure.

West of lon. 102°.			From lon. 86° to lon. 102°.			East of lon. 86°.		
Station.	Lat.	Cases.	Station.	Lat.	Cases.	Station.	Lat.	Cases.
Fort Benton	47° 52′	7	Pembina	49° 0′	9	Cape Rosier	48° 52′	4
Portland, Or.	45 30	1	Duluth	46 48	1	Father Point	48 31	4
			Marquette	46 33	1	Chatham	47 1	8
			Breckenridge	46 16	29	Quebec	46 48	1
			St. Paul	44 53	3	Sydney	46 8	1
			Fort Sully	44 39	8	Montreal	45 31	2
			LaCrosse	43 48	6	Alpena	45 5	1
			Milwaukee	43 3	1	Halifax	44 39	3
			Yankton	42 45	13	Brockville	44 31	2
			Chicago	41 52	2	Burlington	44 29	2
			Davenport	41 30	2	Kingston	44 12	6
			Omaha	41 16	1	Portland, Me.	43 40	2
			Leavenworth	39 19	6	Port Stanley	42 40	2
			St. Louis	38 37	1	Toledo	40 39	1
			Cairo	37 0	2	Baltimore	39 18	1
			Nashville	36 10	2	Lynchburg	37 18	1
			Fort Gibson	35 43	1	Norfolk	36 51	1
			Memphis	35 8	2	Knoxville	35 56	1
						Augusta	33 28	2
						Charleston	32 45	1

The observations at each of these stations cover the entire period of twenty-six months, with the following exceptions, viz., the observations at Pembina commenced in November, 1872; those at Halifax, in December, 1872; at Yankton and Fort Gibson, in April, 1873; at Chatham, in October, 1873; at Cape Rosier, Father Point and Sydney, in November, 1873; and at Brockville, in January, 1874. We see that cases of high barometer occur most frequently at the northern stations. About two-thirds of the whole number were north of latitude 44°, and only fifteen per cent of the whole number were south of latitude 40°. Only one of the cases occurred beyond the Rocky Mountains; and on the east side of the mountains high barometer is most frequent near the meridian 97°. After making allowance for the unequal period of observation at the different stations, we find that in the neighborhood of Dakota, cases of very high pressure are nearly twice as frequent as they are at a corresponding latitude near the Atlantic coast. This fact appears still more palpable if we make the comparison for pressures as high as 30·9 inches. In the region between longitude 86° and 102° the barometer rose as high as 30·9 inches in fifteen cases, while only one such case occurred in the district east of longitude 86°, and none occurred in the district west of longitude 102°.

The low temperature generally attending these high pressures is very remarkable. The lowest temperature observed in any case was −36° Fahrenheit at LaCrosse. In seven cases the ther-

mometer fell as low as −30°, and five of these cases occurred at Breckenridge. In more than half of the whole number of cases the thermometer fell as low as zero of Fahrenheit. The highest temperature reported in any one of these cases was 48° at Cape Rosier, September 18.2, 1874. This is a station where the daily range of temperature is unusually small, being influenced by the temperature of the Gulf of St. Lawrence. In all of these cases the average temperature at Breckenridge and its vicinity was very much lower than at any of the stations east of longitude 86°.

The fact that the region of lowest temperature is also the region of highest pressure cannot be regarded as accidental. The low temperature of the air increases its density, and thus contributes to increase its pressure. This point will be further considered on page 16.

With a single exception, these areas of high barometer appeared to come from British America. About half of them appeared to originate on the west side of the chain of the Rocky Mountains and half on the east side; but on account of the small number of stations of observation it is impossible to trace these areas of high pressure satisfactorily to their origin. Each area of high pressure appears to have commenced with a moderate elevation above 30·00 inches; this elevation gradually increased as the wave advanced, and generally attained its maximum over Dakota or Minnesota. In one case (Jan., 1873,) an area of high barometer prevailed in the Southern States which cannot be traced to British America. This area of high pressure seems to have been first developed in the neighborhood of Arkansas, and increased slowly in magnitude as it drifted eastward, attaining a height of 30·66 inches at Charleston, January 12th, 1873.

In nearly all of these cases an area of low pressure immediately preceded the area of high pressure. When the center of high pressure is west of the Mississippi, an area of low pressure is almost invariably indicated by the observations near the Atlantic coast. When the center of high pressure is near the Atlantic coast, there are no stations of observation where this low pressure on the east side could be shown, but generally an area of low pressure had prevailed in the same region a day or two previous. This was the case in Nos. 1, 10, 17, 21, 23 and 30. The only case in which an area of high pressure was not immediately preceded by an area of low pressure on the east side was No. 9. This case, which has already been referred to, apparently resulted from an area of low pressure prevailing in the northern part of the United States. We thus find that areas of very high pressure are almost invariably preceded by an area of low pressure on the east side, generally at a distance of about 1,200 miles.

Nearly all of these areas of high pressure were immediately followed by an area of low pressure on the west side. When the center of high pressure reached the middle of the continent, an area of low pressure was almost invariably indicated by the observations near the Pacific coast. As long as the center of high pressure was near the Pacific coast, there were no stations of observation where this low pressure on the west side could be shown, but generally an area of low pressure made its appearance in the same region within two days after the passage of the center of high pressure. Nos. 18, 19, 20, 27, 28 and 32 were of this kind.

The only cases in which an area of high barometer was not followed by an area of low barometer within two days, were Nos. 2, 3 and 5. In No. 2, an area of high barometer, which advanced eastward very slowly, was immediately succeeded by another area of high barometer, and no considerable low was formed between them within the limits of the United States, but a low was apparently formed in Canada. In like manner, No. 3 was immediately succeeded by another area of high barometer, and no considerable low was formed between them. In No. 5 a low area was apparently in process of formation on the west side, when another area of high pressure pushed in from the north and filled up the low area. Thus we see that an area of unusually high pressure is almost invariably succeeded by an area of low pressure on its western side, at a distance of about 1,200 miles, but occasionally a new area of high pressure pushes on immediately after the first, and prevents the formation of any considerable area of low pressure.

Areas of unusually high pressure are thus seen to be generally accompanied by areas of low pressure both on the east and west sides, and at an average distance of about 1,200 miles. Sometimes an area of high pressure is broad enough to cover the entire continent from ocean to ocean, as in November 17, 1872, January 24, 1874, February 1 and 2, 1874, and February 24, 1874; but generally when a center of high pressure is near the middle of the continent, an area of low pressure is found to be passing off on the east side, and another area of low pressure coming on upon the west side. This will appear from an inspection of the Table on pages 8, 9 and 10. Sometimes the same map shows an area of very high pressure in Minnesota, with areas of very low pressure both on the Atlantic and Pacific coasts. Such was the case December 23, 1872; December 26, 1872; January 27, 1873; March 4, 1873; November 29, 1873; January 15, 1874, and April 12, 1874. The case of January 15, 1874, is remarkable for the great difference between the maximum and the minimum pressures; and the case of April 12, 1874, is remarkable for the small distance between

the two centers of low pressure. Plate III represents the isobars for this date, and shows a maximum pressure at Alpena amounting to 30·66 inches, with a minimum on the east side of 29·49 inches at Sydney; and a minimum on the west side of 29·49 inches at Fort Sully.

The direction of the wind is shown by the arrows, and its force is shown by the number of feathers attached to the end of the arrow. One feather indicates a velocity not exceeding five miles per hour; two feathers indicate a velocity from six to ten miles; three feathers, from eleven to fifteen miles; four feathers, from sixteen to twenty miles, and so on for higher velocities.

Plate I accompanying my fifth paper represents an area of high barometer near the Mississippi River, with an area of low barometer in Oregon. There was at the same time an area of low barometer on the east side, which had just passed beyond the limits of the chart.

One of the most remarkable circumstances attending these areas of high pressure is the force of the northerly wind which precedes their formation. The following Table shows the direction and force of the wind (in miles per hour) at certain stations at the time of formation of each of the areas of high barometer mentioned in the Table on pages 8, 9 and 10.

No. 1.—1872, Oct. 27.1, Quebec, wind N. E. 33.

No. 2.—Nov. 12.2, Fort Sully, N. 40; Nov. 13.2, Breckenridge, N. W. 45; Nov. 13.3, Breckenridge, N. W. 40; Nov. 14.1, Fort Sully, N. W. 42; Breckenridge, N. W. 40; Nov. 14.2, Breckenridge, N. W. 36; Pembina, N. W. 30; Nov. 15.1, Breckenridge, N. W. 36; Pembina, N. W. 32; Nov. 15.2, Breckenridge, N. W. 47; Omaha, N. W. 30; Nov. 15.3, Pembina, N. W. 38.

No. 3.—Nov. 16.3, Breckenridge, N. W. 30; Nov. 17.1, Breckenridge, N. W. 28; Nov. 18.2, Fort Sully, N. W. 32.

No. 4.—Nov. 27.1, Grand Haven, N. W. 32; Milwaukee, N. W. 41; Nov. 29.2, Quebec, N.E. 57; Nov. 29.3, Quebec, N.E. 42.

No. 5.—Dec. 8.1, Quebec, N. E. 41; Dec. 8.2, Escanaba, N. W. 30; Dec. 8.3, Milwaukee, N. W. 30; Dec. 9.1, Milwaukee, N. 36; Dec. 9.2, Cape May, N. W. 36; Dec. 9.3, Philadelphia, N. W. 36; Dec. 10.1, New York, N. W. 36.

No. 6.—Dec. 20.1, Quebec, N. E. 33; Dec. 21.2, St. Louis, N. W. 38; Dec. 22.1, Cape May, N. W. 34.

No. 7.—Dec. 22.2, Breckenridge, N. W. 33; Fort Sully, N. 34; Dec. 22.3, Breckenridge, N.W. 40; Dec. 23.1, Chicago, N.W. 32; Grand Haven, N.W. 33; Dec. 23.3, Philadelphia, N. 32.

No. 8.—Dec. 26.1, Milwaukee, N. E. 30; Dec. 26.2, New London, N. 32; Dec. 26.3, New York, N. W. 30; Dec. 27.1, Milwaukee, N. W. 30; Dec. 27.2, Grand Haven, N. W. 30.

No. 9.—1873, Jan. 9.1, Breckenridge, N.W. 32; Fort Garry, N.W. 31; Pembina, N.W. 36; Jan. 9.2, Breckenridge, N.W. 35.

No. 10.—Jan. 12.3, Breckenridge, N. W. 40; Jan. 13.3, Kingston, W. 22.

No. 11.—Jan. 15.1, Breckenridge, N. W. 35; Jan. 17.1, Cairo, N. 38.

No. 12.—Jan. 27.2, Breckenridge, N. 40; Fort Sully, N. W. 32; Jan. 28.2, Oswego, N. W. 28.

No. 13.—Jan. 30.1, Fort Sully, N. W. 34.

No. 14.—March 1.2, Fort Garry, N. W. 23; March 1.3, Breckenridge, N. 25; March 2.1, Escanaba, N. 35; March 2.2, Escanaba, N. 32; March 3.2, Cape May, N. W. 32; Philadelphia, N. W. 30; March 3.3, Cape May, N. W. 36; Philadelphia, N. W. 30; Washington, N. W. 32; March 4.1, Cape May, N. W. 32; March 4.2, Cape May, N. W. 30.

No. 15.—March 24.2, Breckenridge, N. E. 30; March 24.3, Breckenridge, N. 30.

No. 16.—Dec. 1.1, Cape Rosier, N. W. 32.

No. 17.—Dec. 3.2, Yankton, N. W. 35; Dec. 3.3, Breckenridge, N. 28; St. Louis, W. 43; Dec. 4.1, Grand Haven, W. 49; Dec. 4.2, Milwaukee, N. 29.

No. 18.—Dec. 8.2, Yankton, N. W. 25; Dec. 10.1, Father Point, N. 25; Quebec, W. 54.

No. 19.—Dec. 18.2, Yankton, N. W. 26; Dec. 19.3, Cape May, N. W. 24; Quebec, N. E. 31.

No. 20.—Dec. 28.2, Fort Sully, N. W. 28; Dec. 28.3, Breckenridge, N. W. 29; Dec. 29.1, Grand Haven, N. W. 32; Dec. 29.2, Oswego, N. W. 28; Dec. 29.3, Grand Haven, N. W. 28; Erie, N. W. 28; Dec. 30.1, Erie, N. W. 28; Cape May, N. W. 28.

No. 21.—1874, Jan. 4.3, Toronto, N. W. 32.

No. 22.—Jan. 12.3, Fort Sully, N. 34; Breckenridge, N. 28; Jan. 13.1, Fort Sully, N. 28; Jan. 14.2, Eastport, N. E. 40; Quebec, N. E. 43; Jan. 14.3, Father Point, N. E. 30; Cape Rosier, N. E. 30; Jan. 15.1, Cape Rosier, N. E. 35; Jan. 15.3, Cape May, N. W. 32.

No. 23.—Jan. 18.2, Yankton, N. W. 40; Jan. 19.1, Escanaba, N. 28; Jan. 19.3, Oswego, N. E. 28; Jan. 20.1, Eastport, N. E. 28; Jan. 20.2, Sydney, N. E. 29.

No. 24.—Jan. 23.2, Philadelphia, N. W. 32; Jan. 24.2, Erie, N. W. 28; Saugeen, N. W. 34; Jan. 24.3, Albany, N. W. 31; Philadelphia, N. W. 30; Cape May, N. W. 38; Jan. 25.2, Oswego, N. W. 28; Eastport, N. 28; Jan. 25.3, Eastport, N. 28.

No. 25.—Jan. 28.1, Quebec, N. E. 47; Jan. 28.3, New York, N. W. 28; Jan. 30.2, Toledo, N. E. 28.

No. 26.—Feb. 4.3, Montreal, N. 26; Feb. 5.1, Eastport, N. 28; Feb. 5.2, Albany, W. 30.

No. 27.—Feb. 20.2, Fort Sully, N. 50; Breckenridge, N. 31; Feb. 20.3, Fort Sully, N. W. 30; Yankton, N. W. 26; Feb. 21.1, Yankton, N. W. 25; Feb. 22.3, Fort Sully, N. 36; Feb. 23.3, Albany, N. W. 34; Feb. 24.1, Norfolk, N. 26.

No. 28.—March 22.2, Detroit, N. W. 34; Escanaba, N. W. 32; Grand Haven, N. W. 36; Milwaukee, N. W. 32; March 22.3, Grand Haven, N. W. 31; Rochester, N. W. 34; Saugeen, N. W. 38; Toronto, N. W. 31; March 23.1, Albany, N. W. 25; Oswego, N. W. 28; Rochester, N. W. 25; Saugeen, N. W. 27; Toronto, N. W. 25; March 23.2, Albany, N. W. 34; Oswego, N. W. 28; Toronto, N. W. 29; Montreal, N. W. 27; Cape Rosier, N. W. 25; March 23.3, Burlington, N. W. 40; Cape May, N. W. 26; Father Point, N. W. 48; March 24.1, Eastport, N. 32.

No. 29.—April 12.1, Albany, N. W. 28; Burlington, N. 26; Eastport, N. 28; April 12.2, Cape Rosier, N. 30; April 12.3, Cape Rosier, N. 32.

No. 30.—Sept. 16.2, Quebec, N. E. 22; Sept. 17.1, Quebec, N. E. 35; Sept. 17.2, Quebec, N. E. 35.

No. 31.—Oct. 9.2, Bismark, N. W. 36; Fort Sully, N. 30; Pembina, N. W. 28; Oct. 10.2, Grand Haven, N. W. 32; Oct. 10.3, Parry Sound, W. 37.

No. 32.—Oct. 28.1, Bismark, N. 34; Oct. 28.2, Cheyenne, N. W. 40; Oct. 28.3, Yankton, N. W. 34; Breckenridge, N. 32; Oct. 29.2, Yankton, N. W. 28; Bismark, N. W. 37; Fort Sully, N. W. 32; Oct. 29.3, Fort Sully, N. W. 28; Quebec, N. 41; Oct. 30.1, Yankton, N.W. 28.

In column 6th of the table on pages 8, 9 and 10 is shown the highest wind which preceded each of these areas of high barometer. We see that these maximum velocities range from thirty to fifty-seven miles, the average being thirty-nine miles per hour. About two-thirds of all these violent winds were from the northwest, and all but six were from some northern quarter. These winds will be seen represented on Plate III.

The facts thus presented seem to confirm the conclusions stated in my eighth paper, and also to warrant some additional generalizations. We see that immediately after a center of low pressure has passed, the wind generally sets in with considerable force from a northern quarter. By the earth's rotation this northerly wind is deflected to the right, and thus is maintained a mechanical rarefaction of the air about the low center. The westward deflection of this current of air produces a mechanical condensation of the air on the western side, so that the same cause contributes to produce an area of low barometer on the east side and an area of high barometer on the west side, and the greater the force of this northerly wind, the greater will be the condensation of the air on the west side of the low area. Thus areas of unusually high barometer are in part the *effect* of the violent north winds which immediately precede them. These north winds come from a region having a very low temperature, so that the air is condensed partly by mechanical pressure, and partly by its low temperature. These northerly

winds push down with unusual force over Dakota and Minnesota, because during the winter months the coldest portion of the American continent is near this meridian, and the contrast between the temperature of Minnesota and that of the Gulf of Mexico is greater than is found for an equal difference of latitude east of the Mississippi.

These considerations do not explain the high barometer in the case of No. 9, and in similar cases which frequently occur in the Southern States; nor do they explain the long continuance which frequently characterizes these areas of high pressure. No. 14 presents a case in which an area of high barometer maintained itself for a week, with a very slow progress towards the southeast, and during all this time the air was blowing outward from the center of high pressure with a velocity of nearly ten miles per hour. This outward movement of the air would have levelled down the area of high barometer in a day or two, if the air thus drawn off had not been replaced from some other source. In the case of April 12, 1874, the outward movement of the air was nearly twenty miles per hour, yet this high area maintained itself for several days with but little diminution while it moved slowly towards the southeast. The supply of air requisite to maintain these areas of high pressure appears to come from the air which ascends from areas of low barometer; and since in the middle latitudes of North America the upper current is generally found moving from the northwest, the supply of air which maintains an area of high barometer, must come chiefly from an area of low barometer situated on its west or northwest side.

This conclusion is confirmed by the observations on the direction of the upper clouds made by the observers of the United States Signal Service, at the dates of the low barometer recorded in my eighth paper. In each of these cases when there was a well-defined area of high pressure on the east side of the area of low pressure within the limits of the United States, I selected all the cases in which the direction of the upper clouds was recorded at stations intermediate between the centers of low and high pressure. The results are given in the following table in which column first shows the date of the observation; column second shows the station; column third shows the direction of the surface wind, and column fourth shows the direction of the upper clouds at the given date and station.

It will be seen that the surface winds were in all cases blowing inward towards the low center, but inclined to the right; that is, they circulated around the low center, and at the same time moved spirally inward. The upper clouds were in all cases moving away from the low center and towards an area of high pressure on the east or southeast side. The movement of the upper clouds was sometimes directed almost exactly towards

Direction of the upper clouds between areas of low and high pressure.

Date.	Station.	Wind.	Clouds.		Date.	Station.	Wind.	Clouds.	
1872.					1874.				
Dec. 24.1	Breckenridge	S.E.	W.	left.	Feb. 11.2	Omaha	S.	W.	right.
1873.						Toledo	E.	W.	right.
Jan. 29.2	Chicago	S.	W.	left.	11.3	Toledo	E.	W.	right.
Feb. 6.2	Breckenridge	S.W.	N.W.	left.	12.1	Alpena	S.E.	S.W.	left.
	Davenport	S.W.	N.	left.		Cincinnati	S.E.	S.W.	left.
Sept. 26.1	Marquette	S.E.	S.W.	left.		Fort Gibson	E.	S.W.	left.
	Milwaukee	S.E.	S.W.	left.		Grand Haven	S.E.	W.	=
	St. Louis	S.	W.	=		Rochester	S.E.	W.	=
	Toledo	S.E.	S.W.	left.		Toledo	E.	N.W.	=
26.2	Alpena	S.E.	S.W.	left.		Toronto	E.	S.W.	left.
	Cincinnati	S.E.	S.W.	left.	12.2	Brockville	N.E.	W.	left.
	Duluth	E.	S.W.	left.		Oswego	S.E.	N.W.	=
	Port Dover	E.	S.W.	left.		Washington	E.	W.	right.
	Toledo	S.	W.	left.	Mar. 1.2	Albany	S.	W.	left.
	Toronto	E.	W.	left.	1.3	Albany	S.	W.	left.
	Washington	S.E.	W.	left.		Ottawa	S.	N.	=
Oct. 17.2	Cleveland	S.E.	W.	right.	6.2	Cincinnati	S.	N.W.	right.
	Louisville	S.	N.W.	right.		Memphis	S.E.	S.W.	=
	Lynchburg	S.E.	N.W.	right.	6.3	Indianapolis	S.E.	S.W.	=
Dec. 3.3	Buffalo	S.	S.W.	left.	16.2	Alpena	S.E.	S.W.	left.
	Cape Rosier	N.E.	W.	left.		Toronto	E.	S.W.	left.
Dec. 31.2	Fort Gibson	S.E.	N.W.	right.	Apr. 12.2	Cincinnati	E.	N.W.	right.
	Indianapolis	S.E.	W.	left.		Davenport	S.E.	W.	=
	LaCrosse	S.	N.W.	=		Dubuque	E.	N.	right.
	Lynchburg	S.	N.W.	left.		Knoxville	E.	W.	right.
	Marquette	S.	W.	left.		Marquette	S.	W.	left.
1874.						Memphis	S.E.	W.	right.
Jan. 2.2	Breckenridge	E.	W.	left.		St. Louis	E.	W.	right.
	Leavenworth	S.	N.W.	right.		St. Paul	S.E.	W.	left.
	Memphis	S.E.	S.W.	left.		Yankton	S.E.	N.W.	right.
	Omaha	S.	W.	left.	12.3	Leavenworth	S.E.	S.W.	left.
	Pembina	E.	S.W.	left.	30.2	Alpena	S.E.	N.W.	left.
	Yankton	S.	N.W.	right.	May 8.2	Leavenworth	S.	N.W.	=
Jan. 2.3	St. Paul	S.E.	S.W.	left.		Port Dover	S.	N.	=
3.1	Fort Gibson	S.E.	W.	=		St. Paul	S.	W.	left.
	Memphis	S.E.	S.W.	left.		Toronto	E.	N W.	left.
3.2	Cincinnati	S.	W.	left.	9.1	Fort Garry	N.E.	W.	left.
	Vicksburg	E.	S.W.	left.		St. Paul	S.	W.	left.
16.1	St. Paul	S.E.	N.W.	left.	9.2	Fort Garry	N.E.	W.	left.
16.2	Escanaba	S.	N.W.	left.		St. Paul	S.	N.W.	=
	Memphis	E.	W.	right.	27.2	Cairo	S.E.	S.W.	left.
17.1	Oswego	S.E.	N.W.	left.		Escanaba	S.	W.	left.
Feb. 11.2	Alpena	E.	W.	=		Fort Sully	S.E.	W.	left.
	Chicago	N.E.	S.W.	left.		Keokuk	S.	N.W.	right.
	Davenport	S.E.	W.	right.		Memphis	N.E.	W.	right.
	Detroit	S.E.	W.	right.		Milwaukee	S.E.	W.	left.
	Escanaba	S.E.	N.W.	right.		St. Louis	S.E.	S.W.	left.
	Fort Gibson	S.E.	W.	right.		St. Paul	S.	W.	left.
	Grand Haven	S.E.	W.	right.					

the center of high pressure; and such cases are designated by the character = in column fifth of the table. Sometimes the direction of the upper clouds was such as would carry them to the right of the high center; and such cases are designated by the term *right* in column fifth of the table. Generally, however, the direction of the upper clouds was such as would carry them to the left of the high center. Such cases are designated by the term *left* in column fifth of the table. We perceive that the movement towards the left of the high center is more than twice as frequent as towards the right; that is, while the movement of the upper clouds is from an area of low pressure towards an area of high pressure, there is a tendency to circulate around the high center in the same direction in which the surface winds circulate around a center of high pressure. Thus we see that near the earth's surface there is a steady but circuitous movement of the air from an area of high barometer towards an area of low barometer where the air ascends, and thence by a retrograde movement it returns to some area of high barometer (perhaps the same one from which it started), where it descends to the surface of the earth and again repeats the same or a similar movement.

A similar circulation of the air is indicated by the observations of temperature at Iceland when compared with observations in Central Europe.

In my fifth paper, page 7, I have shown that according to observations of fifteen years, a temperature *above* the mean in Iceland is generally accompanied by a temperature *below* the mean in Central Europe, and the contrast is most decided during the colder months of the year. I have recently received the Journal of the Scottish Meteorological Society, vol. iii, N. S., which furnishes the mean temperature of each month in Iceland, from November, 1845, to December, 1871, a period of twenty-six years, and I have compared the temperature of each month with the average temperature of that month for the entire period. In the Sitzungsberichte der Akademie der Wissenschaften zu Wien, December, 1866, is given the mean temperature of each month at Vienna, from 1775 to 1864, together with the difference between the temperature of each month and the mean temperature of that month as derived from observations of ninety years. The temperature of Vienna from 1865 to 1872, is given in Jelinek's Jahrbücher für Meteorologie, 1871, page 189. Upon comparing the departures from the mean temperature at Iceland and Vienna for these twenty-six years, we obtain nearly the same result as had been previously deduced from observations of fifteen years. The following table shows the comparison for three months, November, December and January, for the entire period of forty-one years. Column second for each month shows *all* the cases in which the

temperature at Iceland was at least 2¼ degrees Fahrenheit (one degree Reaumur) above the mean, and the year is shown in column first. Column third shows how much the temperature at Vienna for the same month was above or below the mean.

Temperature of Iceland and Vienna compared.

November.			December.			January.		
	Iceland.	Vienna.		Iceland.	Vienna.		Iceland.	Vienna.
1827	+5°·1	−7°·1	1826	+2°·6	+ 4°·3	1823	+4°·1	−10°·2
32	2·7	−3·0	28	6·2	+ 3·7	28	4·5	+ 0·4
35	3·6	−8·0	29	4·1	−13·4	29	2·3	− 3·7
46	5·0	−3·8	31	3·2	− 0·3	30	4·3	−11·9
51	2·9	−4·5	34	6·1	+ 3·1	33	3·1	− 7·5
55	3·6	0	35	2·9	− 4·0	47	9·9	− 3·7
57	5·3	−3·5	49	5·0	− 3·4	48	2·5	−11·0
58	2·5	−8·1	50	5·9	+ 0·7	51	5·5	+ 0.9
64	4·3	−1·8	51	7·0	+ 0·1	61	5·3	− 3·6
67	3·5	−1·8	53	5·2	− 8·4	62	3·9	− 1·6
70	2·7	+4·8	58	2·9	+ 0·9	64	3·4	− 9·0
Mean	+3·7	−3·4	61	3·5	− 2·7	69	5·1	− 0·2
			64	3·0	− 6·6	70	2·9	+ 0·4
			75	3·6	+ 1·1	Mean	+4·4	−4·7
			67	2·3	− 1·1			
			71	3·4	−10·1			
1827	+5·1	−7·1	Mean	+4·2	−2·3			
29	+0·1	7·7				1828	+4·1	−10·2
32	+2·7	3·1	1829	+4·1	−13·4	26	−0·4	8·2
35	+3·6	8·0	32	−0·6	3·0	29	+2·3	3·7
46	+5·0	3·8	35	+2·9	4·0	30	+4·3	11·9
47	−2·7	2·8	46	+0·9	3·3	31	+0·6	3·2
49	−0·2	2·7	49	+5·0	3·4	33	+3·1	7·5
51	+2·9	4·5	53	+5·2	8·4	47	+9·9	3·7
53	+1·2	2·5	55	+0·9	10·8	48	+2·5	11·0
54	−0·6	3·6	59	−6·0	6·1	50	+1·4	6·6
56	−0·7	6·3	61	+3·5	2·7	58	+0·7	3·1
57	+5 3	3·5	64	+3·0	6·7	61	+5·3	3·6
58	+2·5	8·1	70	+2·1	5·4	64	+3·4	9·0
60	+1·8	3·3	71	+3·4	10·1	71	+1·6	5·1
Mean	+1·9	−4·8	Mean	+2·0	−6·4	Mean	+3·0	−6·7

It will be seen that for the years here named, the average temperature of Iceland in November was 3·7 degrees (Fahrenheit) above the mean, while that of Vienna was 3·4 degrees *below* the mean; and for the three months compared, the temperature of Iceland was 4·1 degrees above the mean, while that of Vienna for the same months was 3·5 degrees *below* the mean. Now if the temperature of Vienna were independent of the causes which affect the temperature at Iceland, the average departure from the mean temperature at Vienna for the months in question should be *zero*, instead of which we find the value 3·5 degrees.

In the lower half of the table, column third contains all the cases in which the temperature at Vienna was at least 2¼

degrees (Fahrenheit) *below* the mean, and column second shows how much the temperature at Iceland was above or below the mean for the same months. It will be seen that for the years here named, the average temperature at Vienna in November was 4·8 degrees below the mean, while that of Iceland was 1·9 degrees *above* the mean; and for the three months compared, the temperature at Vienna was 6·0 degrees below the mean, while that of Iceland was 2·3 degrees *above* the mean. If the temperature at Iceland were independent of the causes which affect the temperature at Vienna, the average departure from the mean temperature at Iceland for the months in question should be *zero*, instead of which we find the value 2·3 degrees. Considering that these are the average results derived from forty-one years of observations, I think it is established that when the temperature of Iceland during the colder months of the year is much *above* the mean, the temperature at Vienna is generally depressed *below* the mean.

It will be noticed that exceptions to this rule do occasionally occur. Thus in December, 1826, '28 and '34, and in November, 1870, the temperature was unusually high both at Iceland and Vienna; also in November, 1847, and December, 1859, the temperature was unusually low both at Iceland and Vienna. In December, 1826 and '28, the temperature was above the mean over nearly the whole of Europe, but in Sicily it was somewhat below the mean. In December, 1834, the temperature was considerably below the mean in Switzerland and Northern Italy; and in November, 1870, the temperature was below the mean in England. In November, 1847, although the temperature was below the mean both at Iceland and Vienna, it was very much above the mean at St. Petersburgh, and throughout a considerable portion of Northern Europe. In December, 1859, the depression of temperature was widely extended, but I have not been able to determine whether it reached to all parts of Europe.

The preceding facts seem to confirm the conclusions which I stated in my fifth paper, that an area of low barometer in Iceland, is usually accompanied by an area of high barometer in Southern or Southeastern Europe, and that during the colder months of the year, Vienna is generally near the center of this high area. I infer also that this area of high pressure is replenished by air which rises from the area of low pressure. This air which ascends near Iceland travels as an upper current towards the southeast, and hence the average direction of the upper current in Europe during the winter months is from about N. 52° W. to S. 52° E.

In preparing the materials for this article I have been assisted by Mr. Henry A. Hazen, a graduate of Dartmouth College, of the class of 1871.

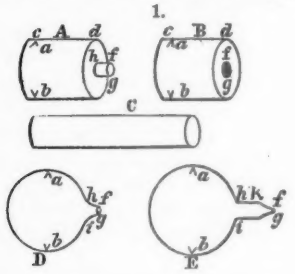
ART. II.—*On Acoustic Repulsion;* by V. DVOŘÁK.

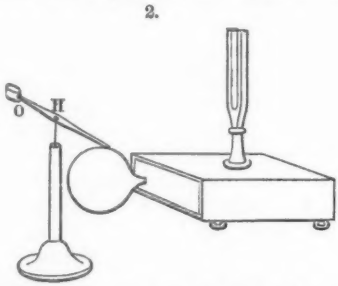
(Translated from Annalen der Physik und Chemie, Band III, No. 3. Dated Agram, 19th November, 1877. With a note by ALFRED M. MAYER.)

(1.) *Acoustic repulsion of resonators which are open at one end only.*—In a previous article "On Acoustic Attraction and Repulsion," I have conclusively proved by theoretic considerations as well as by experiments, that the average pressure at the node in a column of air vibrating in stationary waves cannot be equal to zero as long as the amplitude of vibration is not infinitely small.

In a resonator, open at one end, as for example a cylinder, we find a node at the closed end. In the interior of the cylinder near its closed end there exists a greater pressure than on the outer surface of this end which is touched by the outside air, as can be easily shown by means of a sensitive manometer.

To obtain resonance the opening of the cylinder is turned toward the source of the sound, and the cylinder is then repelled by the excess of pressure within. Resonators not having a cylindrical form, but open at one end, are also subject to such repulsion. In my previous communication I have indicated means for observing the acoustic repulsion of resonators.





As the method described there is not very sensitive, I have replaced it by the following. The resonators here employed are usually made of stiff drawing paper covered with gum Arabic and have the shape of the cylinder with a little paper tube *h f*, at one end; fig. 1, A. This little tube may also be omitted as in fig. 1, B; in that case the resonator is tuned by increasing or diminishing the little opening, *f g*. Even a cylindrical tube open at one end, fig. 1, C, may serve our purpose as a resonator. Spherical resonators of glass, fig. 1, D, which a practiced glass-blower can make as light as paper resonators, are excellent. The note of the resonators is determined by gently blowing over the opening or by tapping.

The resonator is fastened with sealing wax to the end of a light wooden rod, the other extremity of which is provided with a counterpoise of lead O, fig. 2. The center of the rod has a glass cap, H, which rests on a needle point.

The best source of sound is a resonant box of a tuning fork, fig. 2. The repulsion is so great that it is apparent even with an ordinary brass Helmholtz resonator, weighing, with the lead counterpoise, 142 grams.* With every tuning fork we must first ascertain whether the air in the resonating box vibrates with sufficient energy, because this is not always the case even with accurately tuned boxes. As the elasticity of the different boards which form the elastic system of the box is not equal, their vibrations may hinder the formation of the node at the bottom of the box; in this case the air on the bottom of the box will vibrate but feebly. We can easily ascertain this fact by accurately tuning the box to the note of the fork and then observing whether the note is considerably weakened by partially covering the opening. If it is not, then the air in the box has but little vibration even if the tone of the fork is powerful. I have, for example, two boxes with excellent tuning forks by König (of 256 vibrations per second), in which the air would in nowise vibrate powerfully. The strength of the vibration of the air was considerably affected by the degree of tightness with which the fork was screwed to the top of the box. The fork is always vibrated powerfully with a bow, and two bits of rubber tubing must be on the bottom of the box. I generally use the fork A_3, of 435 vibrations per second, by König. Repulsion is then plainly visible with glass resonator at a distance of ten centimeters from the opening of the box. With a large C fork of König (of 128 vibrations) which sounds for more than ten minutes, it was apparent at a distance of twenty centimeters.

The resonators may be tested either by the reinforcement of the sound produced with a tuning-fork, or by the weakening of the sound on approaching them to the opening of the box.† It is not possible to obtain the repulsion of resonators from the prongs of a tuning fork alone, as their aerial vibrations are too weak. (Compare Pogg., clvii, p. 42). I formerly tried in vain to obtain acoustic repulsion from vibrating bodies without the aid of resonance. I suspended small resonators before the end of a glass tube vibrating longitudinally and provided with a cork to increase the vibrating surface. The open end of the resonator was probably too near the end of the fork, and so produced a lowering of the tone and acoustic attraction instead of repul-

* The apparatus represented in fig. 3 may be also used to show acoustic attraction by turning the closed end of the resonator toward the box.

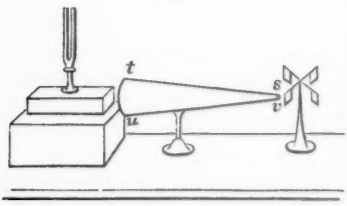
† This is perhaps connected with a conversion of the aerial vibrations in the box into the work of repulsion. The *vis viva* of the sound-vibrations disappears to re-appear as work.

sion. Attraction is probably present in all cases and can assert itself only when not counteracted by greater repulsion.* Later I obtained repulsion very easily in a longitudinally vibrating glass tube 127 centimeters long and 27 millimeters in diameter, on the end of which was a cork 46 millimeters in diameter. One of the resonators used was spherical, fig. 1, B, and another cylindrical, C.

I also obtained powerful repulsion with a circular disk 31 centimeters in diameter and 2 millimeters thick, made by König. The plate was fastened in the center in a vertical position and made to vibrate in six segments, producing a note of 208 vibrations. The resonator was made of stiff paper of the form of B, fig. 1; *a b* equal 80 millimeters, *c d* 140 millimeters, *f g*, equal 17 millimeters, and its opening was placed in front of the center of a vibrating segment, or ventre.

(2.) *The Acoustic Mill.*—A continuous rotation is easily obtained on the principle of the acoustic repulsion of resonators by fastening four very light paper or glass resonators upon two wooden rods, *o, p; r, q*, fig. 3, crossing at right angles, and balanced on a glass cap. All the openings of the resonators fronting one side in the direction of tangents. The whole apparatus is placed before the opening K of the resonating box and fork, in the manner indicated in fig. 3. The open end *a* of resonator, 1, is repelled from K; the closed end B of resonator 2, is attracted, but in general this attraction does not increase the rapidity of rotation, because it counteracts rotation the moment the resonator, 2, has changed its position about 45°. It is therefore not possible to obtain continuous rotation by means of acoustic attraction, as I have shown by numerous experiments.† The resonator, 1, continues to move by reason of its inertia and resonator 2 takes its place, being in turn repelled, and so on.

3.



A very rapid rotation is obtained by using a large Kundt's tube and placing a small acoustic mill before its open end.

The glass tube (Kundt's) which vibrates longitudinally and produces the tone, is fastened to a heavy table, and protrudes

*These experiments were also described in a previous communication. In the apparatus represented, fig. 2, repulsion is easily converted into attraction by diminishing the opening of the resonator with wax, and so throwing it out of tune.

†Instead of the resonators, fig. 3, I used vertical paper vanes, varying the curvature without achieving any results, notwithstanding the fact that there was a pretty strong acoustic attraction for each separate vane.

only a short distance through the cork into the glass tube, placed upon a separate table so that its open end projects somewhat beyond the edge of the latter. The length of the rod was 127 centimeters, the diameter twenty-seven millimeters; the half wave length of its note, $\frac{\lambda}{2}$, equals ten and one-half centimeters. The length of the tube was 45 centimeters, the length of the vibrating column of air, corrected for the open end, was $3\frac{\lambda}{2}+\frac{\lambda}{4}$; the inner diameter was five centimeters.

(3.) *The Acoustic Torsion Balance.*—If we hang by a wire a wooden rod provided with a resonator, like the beam of a Coulomb's torsion-balance, in a case having an opening in the side turned toward the resonator, we can compare the intensity of notes having an equal number of vibrations by means of the repulsion of the resonator; but further experiments are necessary to test the practicability of this method. The sound proceeded from an open pipe, having the note A (of 435 vibrations). To prevent the current of air which passes through the pipe from striking the resonator attached to the balance, we must cut the pipe exactly in the middle of its node, and insert a slack membrane softened with glycerine. To prevent the air, issuing from the mouth of the pipe, from impinging on the resonator, a broad box is used which surrounds the mouth of the pipe air-tight. This box is open on the side opposite the resonator so as not to impair the tone. The pipe is sounded by means of a König's acoustic bellows with a uniform blast of air. The distance of the resonator from the mouth of the pipe must be at least two or three centimeters, to avoid a change of pitch.

(4.) *Production of aerial currents by Sound.*—It may easily be proved by simple theoretic considerations that the mean pressure at the node of a column of air is greater than at its ventre, and that it steadily diminishes in passing from the node to the ventre, provided that the amplitude of vibration is not infinitely small.

It would seem that this difference of pressure would be neutralized by the passage of the air from the node to the ventre. There would then be produced a mean pressure in the whole column, which would be greater, however, than that of air at rest. Consequently air would issue from the opening of the vessel in which it forms stationary waves. I have not succeeded so far in making the whole process clear, for in reality no perfect balance of pressure takes place. The manometer always shows a slight excess of pressure even at the ventre, but this excess increases as we pass to the node. All my previous experiments indicate moveover that a current of air

passes from the node to the ventres, at least in Kundt's tube, in which the air waves are very powerful. This *principal current* lasts as long as the air vibrates. Besides, the same experiments show a continuous secondary current, close to the walls of the tube and in a direction contrary to that of the principal current, so that the whole air in the tube is in circulation. The cross section of the principal current is nearly as great as that of the tube, while that of the secondary current is a very narrow ring.

The excess of pressure as shown by a manometer at the node is always less than the theoretical pressure, because in the latter the air is not supposed to move from the node and to equalize the pressure. Of course the excess of pressure at the ventre is not equal to zero, as theory requires. Probably the friction of the walls has much to do with these phenomena. It may be expected from what has been said that the air will issue from the vessel in which it vibrates in stationary waves. The manometer shows in the first place that the excess of pressure is not equal to zero in the plane of the opening of a resonator because a portion of the air immediately in front of this opening partakes of this stationary wave motion, and because there is always a small excess of pressure even in the ventre of a stationary wave. There is no doubt that a partial equalization of pressure takes place at the opening; experiments show, furthermore, that there is a continuous exit of air which, as in Kundt's tube, is probably neutralized by a secondary and contrary current.

The exit of the air can easily be proved, as follows: a spherical glass resonator is placed before the resonant base of a tuning fork, the resonator is filled with tobacco smoke, strong vibrations are given to the fork, when the smoke will be seen to rush from the resonator.

The current of air proceeding from a resonator is well shown by means of a Chladni plate, by means of lycopodium, which accumulates upon the ventres in little heaps when the plate is sounded. If now we place the opening of a bottle, or bottles of a resonator, B, over such a heap, the lycopodium is immediately blown about in a circle and may be scattered in any direction by giving suitable inclinations to the resonator. A glass plate held over a heap of lycopodium produces the opposite effect by causing it to contract.

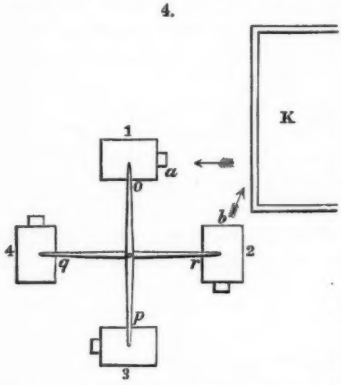
I have succeeded in producing comparatively strong currents of air in still another manner, but I have not yet found an explanation of these complicated phenomena.

A cone made of stiff paper was held with its large end opposite the opening of a large Kundt's tube. The size of this cone may vary, but its effect is greatest when it vibrates to the same note as the Kundt's tube, and so forms a resonator open

at both ends; the diameters of its open ends are thirty-seven and seven millimeters and its length ninety millimeters.

When the Kundt's tube begins to sound loudly a current of air issues from the narrow end of the cone with such violence that it easily blows out of the flame of a candle at a distance of twenty centimeters. This current rushes through the cone with a peculiar noise and is easily felt with the finger.

4.



The cone may be replaced by a cylinder having the width of the Kundt's tube, open at the end turned toward the latter, and closed all but a small hole at the end, but the current is much weaker, nevertheless it will move a small wheel with vertical paper vanes, fig. 4.

In the experiments with the tuning forks, it is essential that the cone should vibrate to the same note as the fork, otherwise the current is too weak. For the fork A (of 435 vibrations), the openings of the cone have diameters of 82 and 3 millimeters, and the length 373 millimeters. The opening at the apex of the cone must be very small to obtain an appreciable current.

On conclusion of this investigation, Dr. R. König kindly communicated to me that Mr. Alfred Mayer in New York [Hoboken] had previously succeeded in producing continuous rotation by means of sound. The communication was as follows: "Professor A. M. Mayer showed me a very similar experiment last summer (1876). He suspended by a thread two large well-tuned flasks attached to a rod, and caused the whole apparatus to revolve by means of a tuning fork. I informed him in consequence that you had previously demonstrated the phenomena of repulsion in resonators, for he was not acquainted with your paper* on acoustic attraction and repulsion."

Note by Professor Alfred M. Mayer.—My connection with the discovery of the Sound-Mill is as follows:

In January, 1876, I made the discovery—first reached by theoretic deductions—that there was more pressure on the inner surface of the bottom of a resounding cavity than on the outer surface of the bottom which touches the outer air. I subsequently proved the truth of this conclusion by experiments on suspended resonators and by observations on the

* Read before the R. Acad. Sci., Vienna in 1875.

motions of precipitated silica powder and films of soap-bubbles placed at various points in resonators of different forms. My first publication of these results was on May 22d, 1876, on which day I read a paper on this discovery before the New York Academy of Sciences, and exhibited before the members an apparatus formed of two + arms of light wood, with a resonator attached to each arm, as in fig. 3 of Professor Dvorák's paper. On sounding an organ-pipe, or a fork on its resonant box, in tune with these resonators, they were successively repelled from the pipe, or fork, and a continuous rotation was exhibited. At the same meeting this experiment was preceded by those on the motions of silica powder, etc., in resonators.

On the 8th of July, 1876, there appeared in the Scientific American a report of this meeting of the Academy, in which my experiments in Acoustic Repulsion are thus referred to:

"In the next place, Professor Mayer exhibited an apparatus constructed by him to produce motion by means of sound pulses. Four glass resonators on cross arms were suspended by means of a string. On sounding an organ-pipe in tune with the resonators, and bringing it opposite the mouth of one of them, the resonator was repelled and the apparatus commenced to rotate. This experiment was the more striking from the fact that, so far from any current of air proceeding out of the mouth of the organ-pipe, the air is actually sucked in, as may be rendered visible by means of smoke from a cigar. The smoke is carried up the pipe even when the latter is closed at the top with cotton wool so as to smother the sound. On substituting disks of cardboard for the resonators, they were drawn up to the mouth of the organ-pipe with considerable force. When fine silica powder was placed in the resonators, it was thrown into violent motion on sounding the pipe."

In the same month, July, 1876, Dr. Rudolph König visited me, and I exhibited the same experiments before him.

The discovery of the acoustic repulsion of resonators and the invention of the sound-mill were made independently by Professor Dvorák and myself. It is another instance of men—even so far distant as Agram and Hoboken—led into the same path of research by the natural growth of science.

Dimensions of the resonators and reaction-wheels used, in millimeters: (1) Fork C, of 128 vibrations. Glass resonator of form E, fig. 1, $a\,b$, equals 90; $h\,i$ 25; $h\,k$ 20; $k\,f$ 33, $f\,g$ 8. Its weight, together with its leaded counterpoise, was 70 grams.

(2) Fork A, 435 (vibrations per second). (*a.*) The glass resonator used in the experiment represented in fig. 2, and to

show the current of air by means of smoke, was of the form D, fig. 1. *a b*, equalled 58, *h f* 22; *f g* 10. (*b.*) The glass resonators of the acoustic mill were of the form D. *a b* equals 34; *h f* 12; *f g* 3. The length of the arms from the middle of the glass caps to the middle of the resonator was 52 millimeters. The weight of the whole wheel was 23 grams. (*c.*) Paper resonators of the acoustic mill, fig. 3, were of the form A, fig. 1. *a b* equals 34; *c d* 50; *h f* 6; *f g* 9 millimeters. The length of the arms was 65; the weight of the whole wheel 9 grams.

(3.) Kundt's tube, $\frac{\lambda}{2}$ equals 105 millimeters. The glass resonators of the acoustic mill were of the form D, fig. 1. *a b* equals 24; *h f* 2; *f g* 7; length of the arms 30 millimeters.

It is a striking fact that very small resonators may give a very deep note; with fork A, I used a glass resonator of the form D, fig. 1, in which *a b* equals 24; *h f* 14; and *f g*, 1 millimeter. The volume was about ninety times less than that of the resonant box of the fork, to whose note the resonator was tuned. Notwithstanding its smallness it showed acoustic repulsion.

ART. III.—*On certain artificial crystals of Gold and Gold Amalgam;* by ALBERT H. CHESTER.

IN casting bars of pure gold for the manufacture of foil, traces of crystallization may often be observed upon their upper surfaces, and sometimes distinct crystalline forms. These are generally simple triangular faces slightly raised, very similar in appearance to specimens sometimes found in nature. Occasionally several faces of the octahedron may be seen, the edge in some instances being half an inch in length, and quite sharp and well defined. The purer the gold is, the more likely the crystals are to form, and they are oftenest seen when the bars are cast from that which has been previously crystallized by the battery process described below. The presence of a very small amount of copper seems to prevent it entirely, and the surface of the bar is quite smooth. It is perhaps worthy of notice that the forms observed are always triangular and never hexagonal, as is so frequently the case with natural crystals of gold. They do not seem to be distorted or flattened at all. Neither do the dendritic forms so common in nature and now quite easily obtained artificially, appear on the surface of the bars.

The precipitation of gold from solution by the aid of a battery is a well known process in the common operation of

electro-gilding, but to deposit it in the crystalline form is a process of comparatively recent date, having been patented in 1860, as a method of preparing gold for dental purposes. The process is briefly as follows. A solution of chloride of gold and ammonium is placed in a shallow dish coated with heavy gold foil, which is connected with the zinc plate of a large Daniells' battery. Near the top of the solution and connected with the copper plate of the battery, a roll made up of thin strips of pure gold is suspended, enclosed in a muslin bag. The strength of the battery current is controlled by a coil of wire arranged as a rheostat, a clamp terminating one of the battery wires enabling the operator to include a greater or less number of coils in the circuit. The necessary conditions being fulfilled, on completing the circuit the gold is gradually dissolved from the roll and deposited on the bottom of the dish in bright crystalline flakes, having the appearance of feathers or fern leaves when examined under the microscope. Fig. 1 shows one of these crystals magnified one hundred and fifty diameters. At first sight this appears to be like certain natural crystals occasionally found, and the arborescent forms of other isometric minerals. But all such crystals that I have seen have invariably the angle of 60° between the side ribs and the midrib, making an angle of 120° between the two sets of ribs. Gold, silver and copper all show this characteristic, which is particularly well illustrated in the crystals described by Professor Vom Rath in the last volume of Groth's Zeitschrift für Krystallographie. It is quite difficult in the case of these artificial crystals to measure their angles, because the midrib is usually more or less curved, and the whole form presents great irregularities. It can only be done approximately for a single crystal, but by making a large number of measurements this difficulty may be in part overcome. The figure above shows a crystal much like the natural ones, the angle on the left of the midrib being about 59° and on the other side 61°. This is an unusually regular one, though I have noticed one still more so, the angles of which measure respectively 60° 36′ and 62° 6′. Fig. 2 represents a crystal such as is most often seen, where the angle on one side is 41° and on the other 79°. The average of fifty measurements of these crystals taken at random is on one side 44° 38′ and on the other 75° 47′. Nineteen measurements made at another time made the two angles 42° 18′ and 78° 24′. The

1.

2

smallest angle noticed was 30° 36′. The following table of several consecutive measurements shows how wide the variation is, the last column giving the total angle between the sets of ribs.

30° 36′	89° 30′	120° 6′
41° 54′	78° 18′	120° 12′
46° 48′	73° 48′	120° 36′
35° 36′	84° 24′	120° 0′
53° 42′	64° 48′	118° 30′
49° 0′	73° 36′	122° 36′
38° 0′	81° 6′	119° 6′
49° 42′	69° 54′	119° 36′

It is noticeable that the same angles are carried out in each crystal, no matter how many branches it may have, and the crystal shown in fig. 2 was selected to illustrate this fact.

I have been quite surprised that no trace of faces is to be observed upon these crystals, as is always the case with natural ones. The latter are seen under a low power to be made up of strings of distorted isometric crystals which are often so distinct that they can be measured. The artificial ones do not show this structure, and when magnified to 300 diameters only show a slightly beaded look along the side ribs, but nothing that can be considered distinct crystalline forms. With the power mentioned the whole surface of each crystal is in focus at once, showing that the different sets of ribs are in the same plane. Fig. 2, with all its branches, was drawn complete without altering the focus of the instrument. Where one crystal lies upon another, when examined under a power of 150 diameters, both are in focus at once, showing that they are exceedingly thin and lie perfectly flat. The power above mentioned, 300 diameters, is the highest with which I have examined them. Possibly with a higher power they might be resolved, and show what is their crystalline form. That they are isometric there is no doubt.

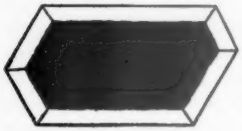
If a film of amalgam is allowed to form on the surface of a piece of pure gold, and the mercury be then driven off by heat, traces of crystallization may sometimes be observed, a network of indistinct crystals remaining. To accomplish this the gold should be perfectly pure, and the heat applied very gently at first. With the greatest pains, however, the result is not always, or even often, satisfactory. The surface is generally left in an amorphous condition, or at best covered with angular depressions. Very rarely, and under conditions not fully understood, the crystallization is distinct enough to be recognized as such. But distinct though minute crystals of gold amalgam may easily be obtained if the mercury is dissolved out with dilute nitric acid, instead of being driven off by

heat. A series of measurements on a number of these crystals proves them to belong to the hexagonal system, having in general the form shown in fig. 3. The average of forty-eight measurements of the prismatic angle is 119° 53′, the six angles of the most perfect one found measuring as follows: 120° 30′, 121° 6′, 119° 12′, 119° 6′, 120° 36′ and 120° 12′. The angle O ∧ 1 has been approximately determined to be about 136°, the roughness of the crystals rendering exact measurement extremely difficult. The pyramidal planes are sometimes entirely wanting, the crystal having only a basal termination. The base is often hollow, in one crystal presenting the appearance shown in fig. 4, the whole base being gone. The sides and bottom of this depression are quite rough, and show no attempt at regularity. Another termination is shown in fig. 5, where part of the base still remains. Fig. 3 was drawn under a power of 300 diameters, the general shape being retained, but the irregularities taken away. It is about 0·5 mm. in length and 0·06 mm. in diameter.

3.

The gold used in preparing these crystals should be pure and in a finely divided condition. I prefer gold precipitated from solution by ferrous sulphate, washed with dilute chlorohydric acid and then with water and dried. This should be treated with about twelve parts of mercury and well triturated in a mortar. The amalgam must then be heated to about 130° C., kept at that temperature for about five minutes, and then allowed to cool gradually. After this it should remain at rest for twelve hours or more. The amalgam, which should be quite fluid, is now to be digested in nitric acid, first of 1·2 sp. gr., and after of 1·4, heating very gently at the beginning, but toward the close of the operation raising it to boiling. The mass left undissolved consists of minute crystals resembling gold in color, but a little darker and having a greenish tinge. They are quite brittle and break with a slight touch. They contain about six per cent of mercury, which may be driven off without injuring the crystals by heating them for a short time to a dull red. The mass will then take the color of pure gold, becoming somewhat spongy, and lose entirely its brittle character. This process was patented in 1853, and used for some time in the preparation of gold for filling teeth, making what was called sponge or crystal gold.

4.



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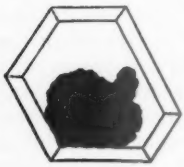


Hamilton College, April 4th, 1878.

ART. IV.—*On a new and remarkable mineral locality in Fairfield County, Connecticut; with a description of several new species occurring there;* by GEORGE J. BRUSH and EDWARD S. DANA. First Paper.

Historical Note.

THE new locality of manganesian phosphates, which we shall describe in this and following papers, is situated near the village of Branchville, in the town of Redding, Fairfield County, Connecticut. Its remarkable character will be evident from the statement that we have thus far discovered, among the material which we have obtained from there, no less than six new and well defined species, besides many other known species of more or less rarity.

The locality was first opened some two years since by Mr. A. N. Fillow, upon whose land it is situated, and who made considerable excavations in the search for mica of commercial value. Only a limited quantity of this was obtained, so that the work was finally discontinued and the opening filled up; by which means the ledge was buried under six to eight feet of soil. With most commendable thoughtfulness, however, he laid aside and preserved a large number of specimens which seemed to him to be of some interest. In the latter part of the summer of 1877, Prof. Dana visited the region and his attention was called by Mr. Fillow to the collection of minerals mentioned, and by him several specimens were brought to New Haven. Later, Rev. John Dickinson of Redding, the adjoining village, happened to visit the locality and obtained a considerable amount of the minerals, some of which he sent to New Haven for determination. It was not, however, until the early spring of the present year that we were able personally to visit the locality. Appreciating then the unusual interest connected with it, we immediately made arrangements with Mr. Fillow to uncover the ledge and to go forward with the exploration as thoroughly as possible. We have now pushed the matter as far as is practicable for the present, but later in the season we hope to accomplish more. The result of our work has been to place in our hands a large amount of material, in the examination of which we are at present engaged, and we are now ready to make public* a portion of the results. In addition to the material we have personally obtained, we have, through the liberality of Mr. Dickinson, come into the possession of a large number of additional specimens collected by

*Short notices of the new species eosphorite, triploidite, dickinsonite, and lithiophilite (by mistake printed *lithiolite*) were published on pp. 398, 481, of the preceding volume.

himself before our first visits to Branchville. These have been of the greatest service to us in the study of the species occurring at the locality, and we would here express our great appreciation of his generosity. We would also mention our obligations to Mr. Fillow and his brother, who have been most careful in obtaining the best results possible in the explorations of which they have taken charge.

Brief general description.

All the minerals which we have obtained are from a single vein of albitic granite, and the line along which the explorations have been carried does not exceed twenty feet. The general description of the vein and of the minerals which compose it—with the exception of the manganesian phosphates and the immediately associated species—we reserve for a later paper; we will mention, however, that outside of these we have identified the following species:—

Albite, quartz, microcline in large masses, a hydro-mica near damourite having a peculiar concentric spherical structure, spodumene in crystals weighing one to two hundred pounds, cymatolite as a result of the decomposition of spodumene crystals, sometimes nine inches in width, apatite, microlite (sp. gr.=6), columbite (sp. gr.=5·6), apatite, garnet, tourmaline and staurolite.

The manganesian phosphates and related minerals occur in nests imbedded in the albite. A single deposit yielded almost all the material obtained, it being probable that what came out as the result of our work was a part of the same body of minerals which Mr. Fillow had blasted into two years before. A second deposit will be mentioned later as having furnished the lithiophilite.

The minerals which form the mass of the first mentioned bed are:—Eosphorite, dickinsonite, triploidite and rhodochrosite. Of these, the first three are new and are described at length in this paper. These four minerals, together with quartz, occur associated in the most intimate manner possible, it being not at all unusual to find all of them in a single hand specimen. This is especially true of the three new minerals: the eosphorite is often found in crystals entirely imbedded in the dickinsonite, and again the finely disseminated plates of dickinsonite give a green color to much of the massive eosphorite. Quartz is also contained in much of the massive eosphorite, thus giving it a very anomalous appearance; it also forms the mass in which the triploidite crystals are imbedded—both these points are spoken of more particularly later. Quartz is also often associated with the rhodochrosite, that mineral being disseminated in crystalline grains through the

quartz, in which occasional brilliant cubes of pyrite are also imbedded.

In addition to the above minerals, as original constituents of the same deposit, are amblygonite (hebronite), and a phosphate of manganese isomorphous with scorodite which we shall describe under the name reddingite. As secondary products we have apatite and quartz coating together crystals of eosphorite, vivianite in thin layers and crystals, besides other species, which as yet, owing to lack of sufficient material for examination, we have been unable to determine.

Furthermore, there are a variety of alteration products: each one of the manganesian phosphates yields on alteration a black or purple phosphate of manganese and iron sesquioxides, and the rhodochrosite gives a pseudomorph of hydrated oxides.

The second smaller nest discovered consisted almost exclusively of lithiophilite. Of the previously mentioned minerals rhodochrosite is the only one we have observed with it, and that occurs very sparingly. In addition, however, a peculiar green manganiferous apatite, spodumene and cymatolite are intimately associated with the lithiophilite, besides the black phosphate produced from its oxidation, and occasional crystals of uraninite and both green and yellow hydrated phosphates of uranium.

From the large amount of black oxidized material, rich in lithia, found with the first deposit it is probable that lithiophilite, or some other similar mineral of the triphylite group, formed one of the original constituents of that mass. In fact it was the discovery of lithia in the black product of decomposition, and its absence in eosphorite, triploidite and dickinsonite, which led us to make further search for the source of this alkali. Fortunately, in the deepest part of our explorations in the vein we struck a small nest which afforded us the fresh unaltered mineral.

We wish here to express our great obligations to Messrs. Samuel L. Penfield and Horace L. Wells of the Sheffield Laboratory, for the excellent analyses which their enthusiastic devotion to the work has enabled us to present in this paper. The carrying through of these analyses has involved in many cases more than usual difficulty, and we appreciate fully to what an extent the value of this article is dependent upon the skill and patient care with which these difficulties have been overcome.

1. Eosphorite.

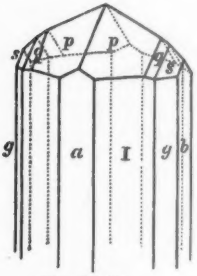
General physical characters.—Eosphorite occurs in prismatic crystals, sometimes of considerable size, which belong to the *orthorhombic system.* They show a nearly perfect macrodiagonal cleavage. It also and more commonly occurs massive, some specimens showing the cleavage finely, but graduating into others which are closely compact. The hardness is 5. For the

specific gravity, three perfectly pure rose-colored specimens gave 3·124, 3·134 and 3·145; mean 3·134. The luster of crystallized specimens is vitreous to sub-resinous, upon cleavage surfaces exceedingly brilliant; of the massive mineral often greasy. The color of the crystals is pink, some having the bright shade common in rose-quartz, while others are paler and have a yellow to gray hue; the smallest crystals are nearly colorless. The massive compact mineral is pale pink, also grayish-, bluish-, and yellowish-white, and white. Some varieties closely resemble in color and luster green elæolite; the green color, however, is shown by the examination of thin sections under the microscope to be due to finely-disseminated scales of dickinsonite. Some varieties again are rendered impure by the presence of quartz through the mass, and they then have a whitish color and granular texture; this subject is expanded in a later paragraph.

The mineral is transparent to translucent. The streak is nearly white, and the fracture uneven to subconchoidal.

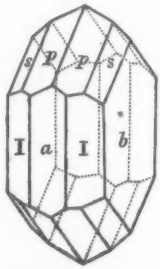
Description of crystals.—Specimens of crystallized eosphorite are rare. The most of those obtained seem to have come from a single cavity, the crystals standing free, and projecting to some length. Again they are found completely imbedded, as, for instance, in dickinsonite. These crystals are in general small; but occasionally imperfect crystals of a considerable size are met with, one of these exposes a width of about an inch, and is two inches long; in another, a single plane has a width of nearly two inches. The planes are seldom well polished, and only in rare cases are exact measurements obtainable. This is due in part to the fact that the surfaces of the crystals are often coated with drusy quartz, and again with minute crystals of apatite, and also because the prismatic planes almost always, and the pyramidal planes very commonly, are finely striated. This striation of the prismatic planes is a marked characteristic and gives rise to rounded barrel-shaped crystals analogous to those observed of tourmaline and many other species.

1.



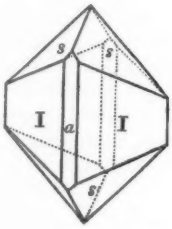
Eosphorite.

2.



Childrenite, Hebron, Me.

3.



Childrenite, Tavistock.

The crystals are invariably prismatic in habit, and show but one terminated extremity; in this respect they differ from the ordinary childrenite of Tavistock, to which it will be shown they are closely related. The general form is shown in fig. 1.

The crystallographic measurements and also the optical examination prove that the crystals belong to the ORTHORHOMBIC SYSTEM.

The fundamental angles were obtained from measurements on a small crystal whose pyramidal planes gave excellent reflections. The mean of a considerable number of readings, whose extremes differed by only $1\frac{1}{2}'$, was taken in each case. A goniometer provided with two telescopes was always employed.

These angles* are as follows:—

$$p \wedge p' \text{ or } 111 \wedge \bar{1}11 = 46° 27' 45''$$
$$p \wedge p'' \text{ or } 111 \wedge \bar{1}11 = 61° 1' 54''$$

From these the following axial ratio is obtained:—

c (vert.)	$\breve{b}$	$\breve{a}$
0·66299	1·28732	1·00000

The observed planes are as follows:

a	i-$\bar{i}$	100†	p	1	111
b	i-$\bar{i}$	010	q	$\frac{3}{2}$-$\frac{3}{2}$	232
I	I	110	s	2-$\bar{2}$	121
g	i-$\bar{2}$	120			

The following is a list of the most important angles both calculated and measured, so far as the last have any value. The angles obtained from the prismatic planes in general, and conspicuously the macropinacoid a (100) were in most cases entirely unreliable.

		Calculated.	Measured.
$I \wedge I$	$110 \wedge \bar{1}10$ =	75° 41′	75° 36′
$g \wedge g$	$120 \wedge \bar{1}20$ =	114° 28′	
$a \wedge I$	$100 \wedge 110$ =	37° 50′	
$a \wedge g$	$100 \wedge 120$ =	57° 14′	
$b \wedge I$	$010 \wedge 110$ =	52° 10′	52° 12′
$b \wedge g$	$010 \wedge 120$ =	32° 46′	
$a \wedge p$	$100 \wedge 111$ =	59° 29′	
$a \wedge q$	$100 \wedge 232$ =	62° 19′	
$a \wedge s$	$100 \wedge 121$ =	65° 13′	
$b \wedge p$	$010 \wedge 111$ =	66° 46′	
$b \wedge q$	$010 \wedge 232$ =	57° 13′	

* The supplement angles, that is, the angles between the normals of the planes, are in all cases given.

† In making the shorter lateral axis a, and giving the symbol 100 to the macropinacoid, and 010 to the brachypinacoid, we follow Groth's Zeitschrift für Krystallographie. With Miller (whose method is adopted in Dana's Text-Book of Mineralogy) the reverse is true.

		Calculated.	Measured.
$b \wedge s$	$010 \wedge 121$	= 49° 21′	
$I \wedge p$	$110 \wedge 111$	= 49° 59′	49° 55′
$g \wedge s$	$120 \wedge 121$	= 39° 13′	
$p \wedge p'$	$111 \wedge 1\bar{1}1$	= *46° 28′	46° 28′
$q \wedge q'$	$232 \wedge 2\bar{3}2$	= 65° 33′	
$s \wedge s'$	$121 \wedge 1\bar{2}1$	= 81° 18′	
$p \wedge p''$	$111 \wedge \bar{1}11$	= *61° 2′	61° 2′
$q \wedge q''$	$232 \wedge \bar{2}32$	= 55° 22′	
$s \wedge s''$	$121 \wedge \bar{1}21$	= 49° 34′	49° 39′
$p \wedge p'''$	$111 \wedge \bar{1}\bar{1}1$	= 80° 2′	80° 0′
$q \wedge q'''$	$232 \wedge \bar{2}\bar{3}2$	= 91° 1′	
$s \wedge s'''$	$121 \wedge \bar{1}\bar{2}1$	= 101° 33′	
$p \wedge s$	$111 \wedge 121$	= 17° 25′	17° 18′

Eosphorite is in crystalline form closely homœomorphous with childrenite. Fig. 2 represents the common form of the childrenite from Hebron, Maine,* as we have found from an examination of the specimens in New Haven. The crystals are sometimes terminated at both extremities as here represented. It is placed in such a position as to correspond with the eosphorite, the pyramid s being identical in the two, as are also the prisms. Fig. 3 shows a common form of the Tavistock crystals; other crystals have the plane b present and resemble fig. 2 more closely in habit. The angles given below show the close relation in form between childrenite and eosphorite.

	Eosphorite.	Childrenite. Tavistock (Cooke.)	Childrenite. Hebron (Cooke.)	Childrenite. Tavistock (Miller.)
$I \wedge I$	75° 41′	75° 24′	74° 20′	75° 46′
$s \wedge s'$	81° 18′	81° 20′	80° 38′	82° 8′
$s \wedge s''$	49° 34′	49° 50′	50° 36′	49° 56′
$s \wedge s'''$	101° 33′	101° 43′	101° 36′	102° 41′

In order to bring the crystals of childrenite into this position the clinodome (2-$\check{i}$, or n of Miller) is made the unit prism.

Optical properties.—A careful examination in the stauroscope proved that the three axes of elasticity coincide with the crystalline axes, showing that the crystals are really orthorhombic. The optic axes lie in the macrodiagonal section, or plane of cleavage, the acute bisectrix (first mean-line) being normal to the brachypinacoid, and the obtuse bisectrix consequently to the basal plane. The axial angle could not be obtained with very great accuracy, owing to the fact that the best sections left much to be desired in the way of clearness. The measurements gave:—

$2E = 54° 30′$ red rays.
$= 60° 30$ blue rays.

The dispersion of the axes is strong, $v > \rho$; the character of the double-refraction is negative.

* This Journ., II, xxxvi, 257, 258.

An examination of a parallelopided cut with its edges parallel to the three axes of elasticity (crystalline axes) showed a very distinct trichroism. The axial colors are as follows:

For vibrations parallel to a (that is $\bar{b}$) yellowish.
b (that is $\dot{a}$) deep pink.
c (that is c (vert.)) faint pink to nearly colorless.

Chemical composition.—The finest of the pink crystals were used for the chemical examination of eosphorite, which was made by Mr. Samuel L. Penfield, assistant in the Sheffield Laboratory. A qualitative analysis having shown the presence of alumina, protoxides of iron and manganese, lime, soda, phosphoric acid and water, the following method was employed in the quantitative separation of the constituents. The total phosphoric acid was determined by means of ammonium molybdate. To determine the bases, one gram of the mineral was fused with sodium carbonate, the fused mass soaked out in water and the solution filtered from the residue of oxides of iron and manganese. Most of the alumina went into solution with the sodium phosphate. The residue of oxides of iron and manganese was dissolved in hydrochloric acid and the iron separated from the manganese by means of a basic acetate precipitation. To insure the complete separation of the alumina from the iron, the precipitate of basic acetate of iron was boiled with sodium hydroxide, the solution filtered off and added to the solution from the fusion, the oxide of iron was then dissolved in hydrochloric acid, the iron precipitated with ammonia and weighed as iron sesquioxide. The iron was then dissolved in hydrochloric acid, evaporated with nitric acid and ammonium molybdate added to precipitate any phosphoric acid which might not have been separated by the sodium carbonate fusion. In this case there was a complete separation. From the filtrate from the basic acetate precipitation, manganese was precipitated by means of bromine, the precipitate dissolved in hydrochloric acid, the manganese again precipitated as ammonio-manganese phosphate and weighed as pyrophosphate. From the filtrates from the precipitation by bromine, lime was thrown down as oxalate. The solutions containing the alumina were acidified with hydrochloric acid, boiled to expel carbonic acid, and aluminum phosphate precipitated by means of ammonia; the precipitate was filtered, washed, dissolved and again precipitated and weighed as aluminum phosphate. As this precipitate is not constant in composition, after weighing, it was dissolved in nitric acid and the phosphoric acid separated by means of ammonium molybdate. The phosphoric acid was determined and deducted from the weight of the aluminum phosphate.

The sodium was determined by precipitating the bases from

an acid solution by means of ammonium carbonate, evaporating the filtrate to dryness, igniting to drive off ammonium salts. The residue was taken up in water, barium hydroxide added to precipitate any phosphoric acid or manganese which might have remained in solution, the excess of barium separated and the sodium weighed as sodium chloride. Care was taken to carry on the evaporations in platinum and avoid contact with glass as much as possible. Water was determined by igniting in a Bohemian glass tube in a gas furnace, the water being collected in a chloride of calcium tube.

Two analyses gave:

	I.	II.	Mean.	Relative number of atoms calculated from the mean.		
P_2O_5	31·10	30·99	31·05	·219	1·	1·
Al_2O_3	21·99	22·40	22·19	·216	·99	1·
FeO	7·42	7·39	7·40	·103		
MnO	23·47	23·56	23·51	·331	·449	2·05	2·
CaO	·54	·54	·54	·010		
Na_2O	·33	·33	·33	·005		
H_2O	15·66	15·54	15·60	·866	3·95	4·
	100·51	100·75	100·62			

The ratio $P_2O_5 : Al_2O_3 : RO : H_2O = 1 : 1 : 2 : 4$ corresponds to the empirical formula $R_2AlP_2O_{10}, 4H_2O$, which may be written $AlP_2O_8 + 2H_2RO_2 + 2aq$. The analogy in the composition of eosphorite to that of childrenite suggests, however, that the better way of writing the formula is:

$$\left\{\begin{matrix} R_3P_2O_8 \\ AlP_2O_8 \end{matrix}\right. + \left\{\begin{matrix} H_2RO_2 \\ H_6AlO_6 \end{matrix}\right. + 4aq.$$

In the formula R corresponds to Mn and Fe with small quantities of Ca and Na_2; the ratio for $Mn : Fe + Ca + Na_2 = 3 : 1$, and for $Mn : Fe = 10 : 3$; for the last ratio the above formula requires:—

	Eosphorite. Calculated from the formula.	Childrenite, analyzed by Rammelsberg.	Childrenite, analyzed by Church.
P_2O_5	30·93	28·92	30·65
Al_2O_3	22·35	14·44	15·85
FeO	7·24	30·68	FeO_3 3·51 FeO2 3·45
MnO	23·80	9·07	7·74
MgO		0·14	1·03
H_2O	15·68	16·98	17·10
	100·00 G.=3·134	100·23 G.=3·247	99·33 G.=3·22

The identity between the crystalline form of eosphorite and that of childrenite has been pointed out in a preceding paragraph, and the analogy between them in chemical composition, and at the same time the wide difference, will be seen from the above. The ratios obtained from the analyses of Rammelsberg and Church for the childrenite from Tavistock and that of eosphorite are as follows:—

		P_2O_5	:	RO_3	:	RO	:	H_2O	
Childrenite	Rg.	3	:	2	:	8	:	15	
	Ch.	4	:	3	:	9	:	18	
Eosphorite		1	:	1	:	2	:	4	and

		P_2O_5	:	RO_3+RO	:	H_2O
Childrenite	Rg.	1	:	$3\frac{1}{3}$	:	5
	Ch.	1	:	3	:	$4\frac{1}{2}$
Eosphorite		1	:	3	:	4

It can hardly be doubted from the above relations and the other facts given that the two species are in fact isomorphous, although the uncertainty that hangs over the composition of childrenite makes it useless to compare the formulas. It is quite possible that, when the composition of childrenite shall be definitely settled, it will be found to be analogous to that given for eosphorite. It cannot be questioned, however, that the two species though closely isomorphous, are at the same time perfectly distinct: the physical characters, the habit of crystals, and method of occurrence speak emphatically for this. Chemically, too, they are not to be confounded, although they may be similar compounds; eosphorite is essentially a phosphate of aluminum and *manganese*, and childrenite of aluminum and *iron*.

Pyrognostics.—In the closed tube eosphorite decrepitates, whitens, gives off abundance of neutral water, and the residue turns first black, then gray, and finally liver-brown with a metallic luster, and becomes magnetic. B.B. in the forceps it cracks open, sprouts and whitens, colors the flame pale-green, and fuses at about four to a black magnetic mass. It dissolves completely in the fluxes, giving iron and manganese reactions. It is soluble in nitric and hydrochloric acids.

In order to make certain that our conclusions that the compact mineral with greasy luster and resembling elæolite was but a variety of eosphorite, we selected a grayish white and apparently homogeneous specimen, which was analyzed by Mr. Horace L. Wells, with the following results:

P_2O_5	26·93
Al_2O_3	18·70
FeO	5·86
MnO	19·21
CaO	2·58
H_2O	12·92
Residue	14·41
Alkalies and fluorine	*traces*
	100·61

An examination of the residue insoluble in acids proved it to consist chiefly of quartz. The 0·144 gram of insoluble residue gave 0·131 silica (92·8 per cent), and contained besides traces of iron, alumina and perhaps other bases. The examination

of a thin section of this variety of eosphorite showed the quartz scattered as grains through the mass.

Deducting the residue from the analysis and calculating again to 100·61, we have

		Atoms.		
P_2O_5	31·43	·221	·221	1
Al_2O_3	21·83	·212	·212	1
MnO	22·43	·316		
FeO	6·84	·096	·466	2
CaO	3·01	·054		
H_2O	15·07	·837	·837	4

This is very nearly the composition of eosphorite as analyzed by Penfield. The excess of lime is in part due to the presence of apatite which is found associated with much of the eosphorite. The compact mineral is simply eosphorite intimately mixed with quartz and other species found at the locality. The greener colored varieties contain dickinsonite and are somewhat more fusible than pure eosphorite, while the lighter colored varieties such as analyzed are more difficultly fusible. The density of these varieties varied from 2·92—3·08.

The name eosphorite is from the Greek ἠωσφόρος (a synonym of φωσφόρος, whence the name phosphorus), which means *dawn-bearing*, in allusion to the characteristic pink color of the crystallized mineral.

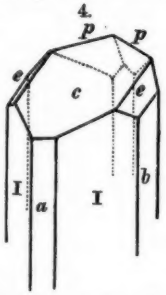
2. Triploidite.

Physical characters.—Triploidite occurs in crystalline aggregates which are distinctly parallel-fibrous to columnar in some cases, and in others divergent; and again confusedly fibrous to nearly compact massive. Occasionally individual prismatic crystals are distinct, being separated from one another by the transparent quartz in which they are imbedded and from which they become detached when the mass is broken into small fragments. The isolated crystals have sometimes a length of an inch or more, but it is not possible to detach them except in very small pieces. The conditions are obviously extremely unfavorable to the formation of terminated crystals, but a careful and long-continued search upon a large amount of material was at last rewarded by the discovery of a few more or less perfect specimens. In rare instances the crystals have been observed standing free in small cavities in the massive mineral. The crystals have perfect orthodiagonal cleavage.

The hardness of triploidite is 4·5–5, and the specific gravity 3·697. The luster is vitreous to greasy-adamantine. The color is yellowish to reddish-brown, in the distinct crystals also topaz- to wine-yellow, and occasionally hyacinth-red. The streak is nearly white. Transparent to translucent. The fracture is subconchoidal.

Crystalline form.—Of the few terminated crystals obtained, three only were suitable for measurement and only one of these had the terminations complete. These were extremely small, but the planes were of so high a luster that they gave good reflections, but little inferior to those obtained from the best eosphorite crystals. The planes in the prismatic zone are in the larger crystals so much striated as to admit of no satisfactory measurements. In the crystals selected for careful measurement the only planes in this zone which could not be used at all were the clinopinacoids, for the others the reflections were reasonably good. The crystals show occasionally false planes, bearing no relation to the axes of the crystal, and which are evidently impressions of portions of adjoining crystals.

4.



The crystals belong to the MONOCLINIC SYSTEM and their habit is shown in figure 4. The axial ratio was obtained from the following fundamental angles:—

$$c \wedge e = 001 \wedge 011 = 54° 48'$$
$$a \wedge I = 100 \wedge 110 = 60° 27'$$
$$a \wedge c = 100 \wedge 001 = 71° 46'$$

These angles are good, though a little less so than those given for eosphorite—the probable error, however, does not exceed $\pm 1'$. The axial ratio is:

c (vert.)	b	d
0·80367	0·53846	1·00000.

The observed planes are:

c,	O,	001.	I,	I_1,	110.
b,	i-i,	010.	e,	1-i,	011.
a,	i-i,	100.	p,	2-2,	$2\bar{1}1$.

The following are the principal angles, both calculated from the above data, and as measured on the same crystal (1) and on the two others (2 and 3):

	Calculated.	Measured. (1)	(2)	(3)
$I \wedge I'$,	$110 \wedge 1\bar{1}0$, = 120° 54′		{ 120° 52′	(3)
$I \wedge I'$,	$110 \wedge \bar{1}10$, = 59° 6′		{ 120° 54′	
$a \wedge c$,	$100 \wedge 001$, = 71° 56′	*71° 56′		71° 55′ (3)
$a \wedge e$,	$100 \wedge 011$, = 79° 37′	79° 36′		
$a \wedge I$,	$100 \wedge 110$, = 60° 27′	{ *60° 27′ { 60° 26′		
$a \wedge p$,	$\bar{1}00 \wedge \bar{2}11$, = 52° 49′	52° 45′		
$b \wedge e$,	$010 \wedge 011$, = 35° 12′			
$b \wedge m$,	$010 \wedge 110$, = 29° 33′			
$b \wedge p$,	$010 \wedge \bar{2}11$, = 48° 33′			
$c \wedge e$,	$001 \wedge 011$, = 54° 48′	*54° 48′		54° 49′ (2)

	Calculated.	Measured. (1)	(2)	(3)
$c \wedge I$,	$001 \wedge 110$, = 81° 7′	81° 6′		
$c \wedge I'$,	$001 \wedge \bar{1}10$, = 98° 53′	98° 52′		
$c \wedge p$,	$001 \wedge \bar{2}11$, = 76° 35′	76° 20′ approx.		
$I \wedge p$,	$\bar{1}10 \wedge \bar{2}11$, = 29° 6′			
$e \wedge I$,	$011 \wedge 110$, = 36° 53′	36° 50′	36° 57′ (2)	
$e \wedge I'$,	$011 \wedge \bar{1}10$, = 51° 33′	51° 24′		
$e \wedge p$,	$011 \wedge \bar{2}11$, = 47° 34′	48° approx.		
$e \wedge e'$,	$011 \wedge 0\bar{1}1$, =109° 36′			
$p \wedge p'$,	$\bar{2}11 \wedge \bar{2}11$, = 82° 53′			

A comparison of the above angles with those given by Brooke and Miller for wagnerite shows that the two species are homœomorphous.

Thus in the three diametral zones, we have :—

	Triploidite.	Wagnerite (Miller).
$I \wedge I'$,	$110 \wedge 1\bar{1}0$,=120° 54′	$g \wedge g$ =122° 25′
$c \wedge a$,	$001 \wedge 100$,= 71° 46′	$c \wedge a$ = 71° 53′
$e \wedge e'$,	$011 \wedge 0\bar{1}1$,=109° 36′	$e \wedge e'$=110° 6′

As the crystal of wagnerite is placed by Miller, the planes g, a, c and e have the symbols (120), (100), (001), (021) respectively. In the figure given by Miller the prism g 120 (= I, (110) triploidite) has the greatest development; it was made the unit prism by Naumann.

Optical properties.—The only point that could be established in regard to the optical character of triploidite was the position of the axes of elasticity. The crystal used for measurement had the clinopinacoid so far developed that it could be examined directly in a Rosenbusch microscope. It was found that of the two axes which lie in the plane of symmetry, one very nearly coincides with the vertical axis, being inclined behind (see fig. 4) 3°–4°, and the other consequently is almost normal to the orthopinacoid. The position of the optic axes could not be fixed. The crystals show no perceptible absorption phenomena.

Chemical composition.—Triploidite was analyzed by Mr. Penfield. This hydrous phosphate was found to contain iron and manganese, both being in the lowest state of oxidation, with a small amount of lime; it is entirely free from fluorine. The method of analysis was substantially the same as that of eosphorite, (described on page 39). There being no alumina in the mineral, the phosphoric acid was determined directly from the solution of the fusion. The fusion did not effect a complete separation of the phosphoric acid from the iron and manganese, as it was retained by the small amount of lime present. It was weighed with the iron, and afterwards was separated from the iron by means of ammonium molyb-

date, determined, deducted from the weight of the latter and added to the phosphoric acid determination. The results of two analyses are:

	I.	II.	Mean.	Relative number of atoms calculated from the mean.		
P_2O_5	32·14	32·08	32·11	·226	1·	1·
FeO	15·07	14·69	14·88	·207		
MnO	48·35	48·55	48·45	·682	895	3·96 4·
CaO	·36	·29	·33	·006		
H_2O	4·01	4·15	4·08	·226	1·00	1·
	99·93	99·76	99·85			

The ratio $P_2O_5 : RO : H_2O = 1 : 4 : 1$ corresponds to the formula $R_4P_2O_9 + H_2O$, or $R_3P_2O_8 + H_2RO_2$, where R=Mn : Fe = 3 : 1. This formula requires:

P_2O_5	31·91
FeO	16·18
MnO	47·86
H_2O	4·05
	100·00

Among the other phosphates and arsenates the following seem to be closely related to triploidite in composition:

Libethenite	$Cu_3P_2O_8 + H_2CuO_2$	Orthorhombic.
Olivenite	$Cu_3(P_2,As_2)O_8 + H_2CuO_2$	Orthorhombic.
Lazulite	$AlP_2O_8 + H_6AlO_6$	Monoclinic.

None of these species has any relation to triploidite in crystalline form. On the other hand the similarity between the angles of wagnerite and triploidite has already been shown; moreover, the composition of triplite is analogous to that of wagnerite and for these reasons a relation between triplite and triploidite immediately suggests itself. The composition of these minerals is:

Wagnerite	$Mg_3P_2O_8 + MgF_2$
Triplite	$(Fe, Mn)_3P_2O_8 + (Fe, Mn)\,F_2$
Triploidite	$(Mn, Fe)_3P_2O_8 + (Mn, Fe)\,(OH)_2$

It should be stated that the perfect transparency and brilliant luster of the crystals analyzed prove beyond all question that the absence of fluorine and the presence of water (determined directly) are not due to any alteration. The fact that all the bases are in the lower state of oxidation would be confirmatory evidence were it needed. The conclusion to which we are led is this—that in the compound triploidite the radical hydroxyl (OH) plays the same part as the element fluorine, the molecule $R(OH)_2$ taking the place of the RF_2.

Pyrognostics.—In the closed tube triploidite gives neutral water, turns black and becomes magnetic. Fuses quietly in the naked lamp flame and B. B. in the forceps, colors the flame green. Dissolves in the fluxes, giving reactions for manganese and iron. Soluble in acids.

An analysis of another specimen of triploidite gave P_2O_5 32·24, FeO 18·65, MnO 42·96, CaO not determined, H_2O 4·09, quartz 1·09. The lime was accidentally lost but calculating from the amount of phosphoric acid retained by the iron it amounted to 0·90 per cent. The analysis is interesting as showing that the iron and manganese vary in different specimens, the darker colored varieties containing the most iron.

The name *triploidite* given to this species, from *triplite*, and *εἶδος form*, indicates its resemblance to triplite in physical characters, and its relation in chemical composition.

(To be continued.)

ART. V.—*On Dinitroparadibrombenzols and their Derivatives;* by Dr. P. TOWNSEND AUSTEN, F.C.S., Assistant Prof. of Chemistry in Rutgers College. Third paper.*

IN my former papers, I have described the formation of three dinitroparadibrombenzols, and proved the α and β variations to be isomeric compounds. With regard to the third, I am still somewhat in doubt.

The peculiar formation of nitroparadibromaniline by treatment of alpha dinitroparadibrombenzol with ammonia, has led me to make experiments with other reagents, and I have been gratified at encountering some quite unexpected phenomena. These I shall mention in another paper.

Beta-dinitroparabromphenol.

By pouring a very concentrated alcoholic solution of potassa over the beta-dinitrodibrombenzol, the mass became scarlet-red, indicating the formation of a salt. Examination showed, however, that much of the substance was left unaffected. On heating, an action set in, and fine bubbles were formed. On diluting with alcohol and acidifying with hydrochloric acid, a dark brown flocculent mass was obtained, insoluble to any extent in alcohol. It was soluble in glacial acetic acid and acetic ether, separating in the form of an amorphous powder. As it was also soluble in a solution of sodium hydrate, and was precipitated therefrom by hydrochloric acid, I take it to be an azoxyphenol.

Various attempts to obtain a good yield of the phenol by direct treatment with potassa, or soda, in different amounts and solvents, did not meet with success, except on a small scale. Although in most cases, the phenol salt was formed, as could be discerned from the red color of the liquid, yet on application

* Compare this Journal, III, ix, 118, and xiii, 95.

of heat, the speedy browning of the liquid showed that a more vital action had taken place. The best results with this method were obtained by long boiling of the dinitrodibrombenzol with an aqueous solution of potassa. Owing, however, to the slight solubility of the nitro-compound in water, but a small amount of the phenol salt was formed.

I then endeavored to utilize a reaction which I described, some time ago,* as taking place between dinitromonobrombenzol and potassium nitrite, when the two substances are heated under pressure in presence of dilute alcohol. The formation of dinitrophenol takes place easily:

$$C_6H_3(NO_2)_2Br+2KNO_2=C_6H_3(NO_2)_2OK+KBr+N_2O_3(?)$$

The resulting oxide or oxides of nitrogen have here the beneficial effect of exerting an oxidizing action. The great objection to the use of an alkali in forming hydroxyl derivatives from nitro-halides, is the tendency it has to affect the nitro-groups converting them into azoxy-compounds. By the use of potassium nitrite all reducing action is avoided—in fact, prevented—by the presence of the nitrogen oxide. The oxides react also on the alcohol present, forming aldehyde.

Some of the β-dinitroparadibrombenzol was dissolved in dilute alcohol, and an equal weight of KNO_2 added. On standing, the KNO_2 extracts the water from the dilute alcohol, forming an aqueous layer on which the alcoholic solution rests. By standing, even without warming, the line of contact between these layers solidifies to a crust of red needles. On boiling, however, the action is soon complete, and every trace of the β-isomer is converted into the phenol. The reaction is precisely analogous to the former:

$$C_6H_2(NO_2)_2Br_2+2KONO=C_6H_2(NO_2)_2BrOK+KBr+N_2O_3(?)$$

Some of the pure α was then treated in a similar manner, but did not suffer the slightest change. Some samples of KNO_2 gave a slight coloration, but this was owing to the presence of free potassium hydrate. They gave no reaction after the potassium nitrite had been moistened with a few drops of dilute nitric acid.

The oil that I take to be a gamma-isomer, also remained unaffected.

This method enables me to overcome several hitherto almost insurmountable obstacles. The separation and purification of the beta from the alpha by crystallization is extremely difficult, and from the gamma almost impossible. By direct treatment with KNO_2, of the mass obtained by nitrition of the dibrombenzol however, all the beta isomer can be extracted in the form of phenol salt, leaving only the alpha, a solid substance

* This Journal, August, 1876.

fusing at 159°, and the gamma, an oil, which I hope will prove easy of separation.

It also forms an excellent test of the purity of the alpha-compound, since the color of the potassium beta-phenylate is so vivid, that if the alpha contains the slightest trace of the beta, it is shown by the formation of a red tint on boiling it with dilute alcohol and potassium nitrite. By treating the beta-compound in the same manner, evaporating to dryness and extracting with hot carbon disulphide, an admixture of the alpha and gamma modifications is easily revealed. In this manner, I have succeeded in proving that several specimens of what I thought to be pure alpha and beta, were not absolutely free from isomers, although the fusing points had long since ceased to show any appreciable variation.

Finally this method promises a means of obtaining phenols by substitution of the halide in those nitro-halides which on treatment with an alkali suffer substitution of the nitro-group.* For if a reaction takes place it is only the halide which can be affected.

Preparation.—150 grams of the raw product, obtained by nitrition of the paradibrombenzol, were treated in a flask with boiling absolute alcohol until all was in solution. The boiling liquid was diluted with hot water until the substance began to permanently separate. Alcohol was then added until solution had taken place, on which water was again added, the liquid being kept boiling all the time. In this manner, by successively adding water and alcohol, the volume of the liquid was brought up to about 1½ liters. The object of this excessive dilution was to prevent the separation of the liquid into two layers from the removal of the water by the KNO_2. The flask was taken off the sand bath, and 100 grms. of KNO_2 carefully added. It was then replaced, and the liquid allowed to boil violently.

The formation of the phenol salt took place quickly. In about half an hour, during which water was occasionally added to replace the loss by evaporation, the reaction was completed. The contents of the flask were poured into a tall beaker holding about 1½ liters of cold water, stirred, allowed to settle, and washed several times by decantation to remove the potassium bromide and unchanged potassium nitrite. The mass was brought on a filter and allowed to drain, after which it was placed in a dish and heated in a water bath till all moisture was driven off. By repeated warming with carbon disulphide, all traces of the unchanged isomers were easily removed. The red salt was then purified by crystallization from dilute alcohol, dissolved in boiling water and carefully decolorized with di-

* As for instance the dinitro-chlorbenzol of Laubenheimer, Ber. d. d. chem. Ges., viii, 1929; ix, 768.

lute* hydrochloric acid (1 : 10), filtered, washed and purified by crystallization from dilute alcohol.†

Analysis.—A combustion gave:

0·2852 grms. of substance yielded 0·2870 grms. of CO_2 and 0·0422 grms. of H_2O.

The formula $C_6H_2\begin{cases}NO_2\\NO_2\\Br\\OH\end{cases}=C_6H_3N_2O_5Br$.

Calculated.	Found.
C=27·38	27·44
H= 1·13	1·64

Properties.—This compound is identical with the dinitrobromphenol obtained by Körner‡ from nitrition of bromphenol. It forms when crystallized from water or alcohol, long, flat, very thin and strongly glittering needles, fusing at 71°. Körner found 78°. On careful heating it volatilizes unchanged. Exposed to the air it soon turns reddish, undoubtedly, as Körner suggested, from the presence of ammonia. Heated under water, it fuses to a yellow oil. It has strong tinctorial powers, dying the skin yellow. In all these properties my observations agree entirely with those of Körner. By heating with concentrated sulphuric acid, decomposition sets in, and a gas is liberated which smells like nitrous acid, while a (sulpho?) acid giving a barium-salt soluble in water, is obtained. When heated on a platinum foil, it burns brightly with a luminous yellow, smoky flame. Thrown on a red-hot platinum foil it puffs.

On heating the phenol with fuming nitric acid a violent action took place. The resulting liquid on evaporation furnish an abundant quantity of *picric acid.*

There are already several instances known where picric acid is formed by the substitution of a halide by the nitro-group. A directly analogous case is quoted by Post‡ who mentions that picric acid is formed by nitrition of the phenol isomeric to this (dinitrobromphenol fusing at 117°).§ This proves conclusively then, that, when a halide is expelled by direct treatment with nitric acid, we are not in a condition to assume that the entering nitro-group takes the same relative position as the antecedent halide; for, as in the case above shown, both the dinitrobromphenols give picric acid on nitrition.

* In many cases the addition of concentrated hydrochloric acid to a hot, concentrated solution of a nitro-phenol salt, will entirely decompose the phenol. If I am not mistaken, this fact has already been noticed, but I cannot recall the reference.

† This compound is also formed when β-dinitroparabromaniline is heated with a solution of potassium hydrate.

‡ Ber. d. d. Chem. Ges., vii, 334.

§ Armstrong, Ber. d. d. Chem. Ges., vi, 649.

It is not a little peculiar that nitric acid should drive the bromine atom out of dinitrobromphenol, forming picric acid; for picric acid when treated with bromine, yields* dinitrobromphenol.

Solubility.—Difficultly soluble in boiling water. Apparently less easily soluble in boiling dilute hydrochloric and nitric acids. Easily soluble in boiling dilute sulphuric acid. In hot alcohol and acetic acid (glacial) very easily soluble. In carbon disulphide, less easily. In hot aniline it is very easily dissolved, giving a red solution.

Silver Beta-dinitroparabromphenylate.

Preparation.—The salt was made by mixing aqueous solutions of silver nitrate and ammonium dinitrobromphenylate. It is difficultly soluble in boiling water, but much more easily in alcohol.

Analysis.—

$$C_6H_2\begin{cases}NO_2\\NO_2\\Br\\OAg\end{cases}=C_6H_2N_2O_5AgBr.$$

0·4903 grams of substance yielded 0·1884 grams of AgCl.

Calculated.	Found.
Ag=29·19	28·90

Properties.—Splendid glittering red needles, having a brilliant green reflex. When dry the salt puffs on heating. If thrown on a hot surface, it explodes.

Potassium Beta-dinitroparabromphenylate.

I have already described the formation of this salt. It is somewhat difficultly soluble in boiling water. It forms long glittering and red needles, having a greenish reflex. This is the only salt that Körner prepared. He considers the play of colors to be like that of murexide.

Barium Beta-dinitroparabromphenylate.

Preparation.—Barium carbonate was boiled with a dilute alcoholic solution of the phenol until all carbonic anhydride was expelled. The residue was extracted with boiling water, filtered and allowed to crystallize.

Analysis.—

$$(C_6H_2(NO_2)_2BrO)_2Ba=C_{12}H_4K_4O_{12}Br_2Ba$$

0·3824 grams of substance gave 0·1331 grams of $BaSO_4$.

Calculated.	Found.
Ba=20·72	20·46

Properties.—Saffron-yellow needles. Moderately soluble in hot water or alcohol. When heated in a mattrass, it explodes, covering the sides with carbon.

* Armstrong, Ber. d. d. Chem. Ges., vi, 650.

Ammonium Beta-dinitroparabromphenylate.

Preparation.—By action of ammonia on an alcoholic solution of the phenol.

Analysis.—

$$C_6H_2(NO_2)_2BrONH_4=C_6H_6N_3O_5Br$$

0·52 grams of substance gave 0·4 grams of $PtCl_4$, 2AmCl.

Calculated.	Found.
$NH_4=6·52$	6·20

Properties.—Bright red silky needles. Soluble in boiling water and alcohol. When heated in a mattrass to 140°, it is volatile, forming a red sublimate which can be driven about by cautious heating. On higher heating it is dissociated into ammonia and phenol. A partial recombination takes place on cooling.

Copper Beta-dinitroparabromphenylate.

Preparation.—It was obtained by action of a slight excess of well-washed $CuCO_3$ on the phenol in boiling dilute alcoholic solution. The resulting mass was dissolved in glacial acetic acid. The salt was thereby decomposed, cupric acetate and free phenol being formed. On diluting the blue solution carefully with water, a point was reached where the color changed to brown. The solution was then allowed to stand. After a short time the substance began to separate in crystals.*

Properties.—The salt crystallizes in short, brown glittering needles. It is insoluble in water and alcohol. Moderately soluble in boiling acetic acid. The best way to obtain it in solution, is to dissolve it in glacial acetic acid, and dilute with water until the blue color changes to brown.

None of these salts contain water of crystallization and differ here from the salts of the isomeric dinitrobromphenol of Armstrong.

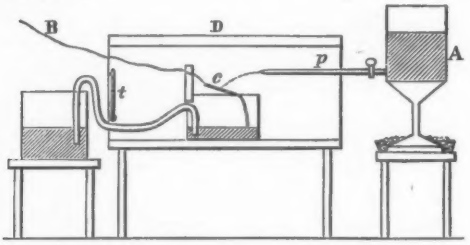
When I found that this phenol could be so easily obtained, I hoped that by action of phosphorous pentabromide, it could be converted back into β-dinitroparadibrombenzol. All attempts in this direction have as yet failed. The larger part of the phenol remains unchanged on treatment with the bromide, while some of it is entirely decomposed.

New Brunswick, N. J., April 1st, 1878.

* It would be interesting to determine exactly at what point of dilution the acetic acid becomes equal to the phenol in its attraction to the copper.

ART. VI.—*The effect of Temperature upon Atmospheric Electricity;* by HENRY GOLDMARK. (Contributions from the Physical Laboratory of Harvard College. No. 24.)

SIR WILLIAM THOMSON, by means of the different forms of electrometers, devised by himself, has investigated the electric potential of the atmosphere under varying conditions and in different localities. The effect of an increase of temperature upon the potential of the air he does not appear to have ascertained, and the following experiments were undertaken with a view of arriving at some conclusion upon this subject. From the nature of the case the measurements made were approximate, and the results reached qualitative rather than quantitative. To get the potential of the air at any point I used the water-dropping apparatus devised by Thomson. Its construction will be readily understood by reference to the sectional view given below.



It consists merely of a can of water A, insulated by standing upon a glass support, and discharging by the small pipe *p* through a fine nozzle. The insulation is made more perfect by drying the atmosphere around the insulating stem by means of small pieces of pumice stone, moistened with sulphuric acid and placed around its base.

The water breaking into drops from the nozzle assumes the potential of the air at the point and communicates it to the copper plate C, from which the insulated wire B leads to the electrometer. In order to investigate the effect of different temperatures upon the potential, it was necessary to have a limited volume of air upon which to experiment. To do this I enclosed the nozzle of the water-dropping tube and the copper plate in the interior of the cylindrical drum D. This drum was made of several layers of sheet iron, so arranged that the air, after being heated by three Bunsen burners below, would pass several times around the cylinder and so raise the temperature of the enclosed air, without otherwise affecting it. The water which dropped from the plate collected in the glass dish below from which it was drained out by a syphon, as fast as it fell.

To *measure* the potential I employed one of Thomson's quadrant electrometers, which was charged sometimes by a Holtz machine and sometimes by the Ruhmkorff coil. This instrument carries a small concave mirror which reflects a spot of light upon a scale of ground-glass placed at the distance of about a meter. In order to avoid any influence which the observer's body near the instrument or conducting wires might make, I observed the deflections upon this scale by means of a telescope from the opposite end of the room.

The method of procedure was as follows: The opposite quadrants of the electrometer were connected with two of the four binding screws of a peculiar key constructed for the instrument, while to the other two the wire coming from the measuring instrument and a wire leading to the earth were respectively attached. The potential of the air in the drum was then measured, the temperature being that of the air of the room. The result showed a very constant negative potential, varying but little in the successive days on which the experiment was made. The potential of the air of the room was also measured at the same time, and found to be the same as that of the enclosed air, thus proving that the drum had no effect upon the electric condition of its contents. The burners were then lighted, and the potential was, from time to time, measured after the temperature of the enclosed air, as observed by the thermometer *t*, had risen above that outside.

The change was by no means marked, but I did not on any occasion, notice any decrease of potential, but on the contrary a small but constant increase on raising the temperature. The following table gives some of the measurements made:

April 21.		April 24.		April 25.	
Temp. in Cent. deg.	Potential in scale div.	Temp. in Cent. deg.	Potential in scale div.	Temp. in Cent. deg.	Potential in scale div.
20½	15½	23	15	22	15½
30	19	50	20½	42	19½
60	20	67	23	74	20½
				88	22
				96	23

On extinguishing the burners and allowing the enclosed air to cool slowly, it retained the maximum potential it had reached on heating, even after it had regained its original low temperature.

As a result of my experiments I arrived at the following conclusions:

1st. That, even a very considerable change of temperature, does not have *any great* or *marked* effect upon the electric potential of the air.

2d. That however a rise in temperature does produce a *slight but constant* increase in the potential.

ART. VII.—*A method of recording Articulate Vibrations by means of Photography;* by E. W. BLAKE, Jr., Hazard Professor of Physics, Brown University.

THE extreme minuteness of the vibrations of the iron disc of the Bell telephone withdraws them from all ordinary methods of observation and measurement. A pointed wire fastened to the center of a ferrotype disc $2\frac{3}{4}$ inches in diameter, and moving on smoked glass, gave $\frac{1}{50}$ inches as the extreme amplitude of vibration under a powerful impulse of the voice, while sounds moderated to such a point as to be fairly articulate, were with difficulty detected by the movement which they communicated.

Animal membranes, possessing greater flexibility than the metal disc, seemed to promise better results, but the inertia of the attached wire, and the resistance offered by the smoked surface, become of importance, and throw doubt on the accuracy of the results obtained. Dr. Clarence J. Blake employs the human *membrana tympani* as a logograph,* and has obtained very beautiful and interesting tracings. I find by examination of some, which he kindly sent me, that the number of vibrations as recorded falls considerably below the ordinary pitch of the voice, being in some cases as low as 80 per second.

The logograph described by W. H. Barlow, F.R.S., in a paper read before the Royal Society,† serves to record the varying pressures of the expelled air taken as a whole. With a single exception the diagrams give no suggestion of the *musical* character of the sounds. The width of the line drawn by a camel's hair brush and the slow movement of the paper would mask the minute vibrations even if the apparatus were otherwise adapted to showing them.

The opeioscope, invented by Professor A. E. Dolbear, consisting of a tense membrane, to the center of which a small mirror is attached, is well adapted to proving the existence of musical vibrations in human speech, but not to determining their character.

The phonograph of Mr. Edison records on tin-foil enough of the vocal elements to reproduce intelligible articulation. The minute indentations are therefore a record of great scientific value. In the hands of Mr. Fleeming Jenkin they promise to lead to valuable results‡ in the analysis of vocal sounds.

Dr. S. Th. Stein§ described in 1876 a method of photograph-

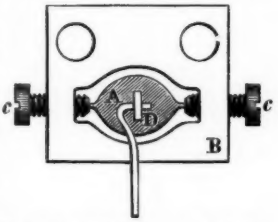
* Archives of Opthalmology and Otology, vol. v, No. 1, 1876.
† Reprinted in the Popular Science Review, London, July, 1874.
‡ Nature, May 9th, 1878. Article on Phonograph by Mr. J. Ellis.
§ Poggendorff's Annalen, Bd. clix, S. 142.

ing the vibrations of tuning forks, strings, &c., by attaching to them plates of blackened mica punctured with small holes. A beam of sunlight passing through the hole strikes a sensitive plate moving with uniform velocity, and leaves a permanent record of the combined motions. Dr. Stein considers his method applicable to *vocal* sounds, but I cannot learn that he has ever attempted this application. My own experiments in that direction by Stein's method resulted in failure.

The object of this paper is to describe a method of obtaining photographs of minute vibrations on a magnified scale.

A plane mirror of steel, A, is supported by its axis in the metal frame B. The ends of the axis are conical, and carefully fitted into sockets in the ends of the screws C, C. On the back of the mirror is a slight projection D pierced by a small hole.

The vibrating disc, as hitherto employed, is a circular plate of ferrotype iron, $2\frac{3}{4}$ inches in diameter, screwed to the back of a telephone mouth-piece of the form invented by Professor John Peirce, and now universally used. From the center of the back of this disc a stiff steel wire projects, the end of which is bent at a right angle. This wire serves to connect the vibrating disc with the mirror by hooking into the hole in D, as represented in the figure. The mirror frame and the vibrating disc are kept in a fixed relation to each other by a block of hard wood, to which both are firmly screwed. The mirror is set with its axis parallel, and its reflecting surface perpendicular, to the vibrating disc.



Back view of Mirror, actual size.

A heliostat sends a beam of sunlight horizontally through a small circular opening. This beam passes into a dark closet and at a distance of several feet from the circular opening falls upon the mirror above described placed with its axis inclined 45° to the horizon. The rays, reflected vertically downward, pass through a lens at whose focus they form an intensely luminous image of the circular opening.

A carriage moving smoothly on four wheels travels beneath the lens at such a distance that the sensitized plate laid upon it comes at the focus for actinic rays. A uniform velocity is given to the carriage by a string fastened to it and passing over a pulley. To this string a lead weight, just sufficient to balance friction, is permanently attached, while a supplemental weight acts at the beginning of motion and is removed just before the sensitized plate reaches the spot of light above described.

The velocity attained by the carriage is determined by placing a sheet of smoked glass upon it and letting it run under a

tuning fork (Ut 3—512 v. s.) provided with a pointed wire. In every case more than 200 vibrations were counted and measured, and careful comparisons made between the earlier and later ones, so as to be certain of the uniformity of the motion.

From the description it will be evident, that when the carriage alone is in motion a straight line will be photographed upon the plate. On speaking into the mouth-piece the disc is set in vibration, each movement causing change of angular position of the mirror, the reflected light moves through twice this angle, and the resulting photograph gives us the combination of its motion with that of the carriage.*

The general character of the curves obtained is shown in the accompanying figures, which are about one-half (0·56) the actual size of the originals. The reduction was accomplished by photography on the wood itself, so that the skill of the engraver was employed simply to follow the lines, which he has done with great fidelity.

The velocity of the carriage for the vowel-sounds was 21½, for *Brown University*, 40, and for *How do you do*, 14 inches per second.

In the mathematical discussion of these curves the abscissas are measured by the known velocity of the carriage, and serve to determine the *pitch*, the ordinates represent the amplitude of vibration of the center of the disc, magnified 200 times in the photographs. The reduction of scale makes the magnifying in the wood-cuts only 112 times.

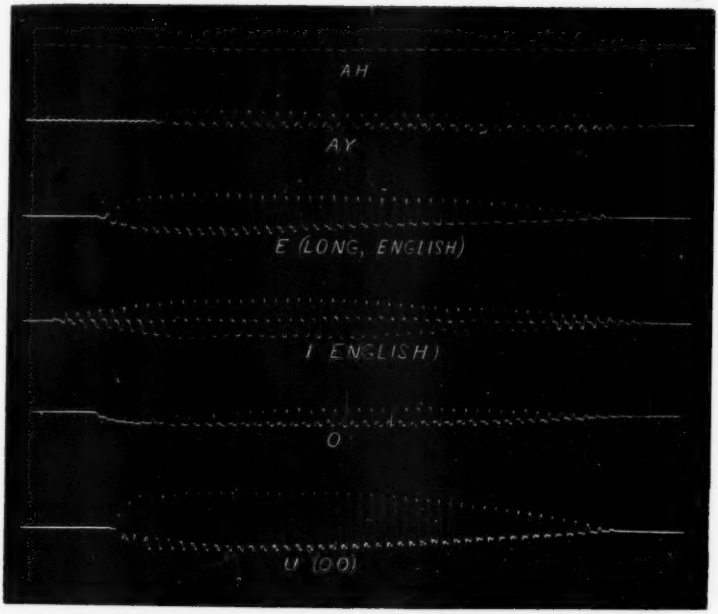
The ordinates are not strictly straight lines, but parts of the vertex of a parabola, and closely approximate to circular arcs whose radius is the focal length of the lens employed.† In the figures given, the centers of curvature of these arcs is at the right hand.

With an ordinary tone of voice an amplitude of nearly an inch is obtained, implying a movement of the center of the disc of ·005 inches as determined by actual measurement.

By varying the accelerating weight and its fall, any manageable velocity may be given to the carriage. Each syllable requires for its articulation about one-fourth of a second, hence

* The carriage should run from *right* to *left*. The negative (examined from the *glass* side), and prints taken from it, then give the syllables in their proper order, and show movements of the disc from the speaker by lines going from the observer. The arrangement of my dark room compelled me to make my carriage move from *left* to *right*; hence, in the figures given, forward positions of the disc are represented by the lower portions of the curves.

† It can easily be shown that the reflected beam describes the envelope of a cone, whose apex has an angle of 90°, and whose axis is inclined 45°. The intersection of this cone with the horizontal plane gives the parabola. The lens employed transfers the apex to its own optical center. The ordinates may be made practically straight lines by placing the mirror with its axis vertical so as to reflect the beam *almost* directly back on its path, and having the sensitized plate move up and down in a vertical plane.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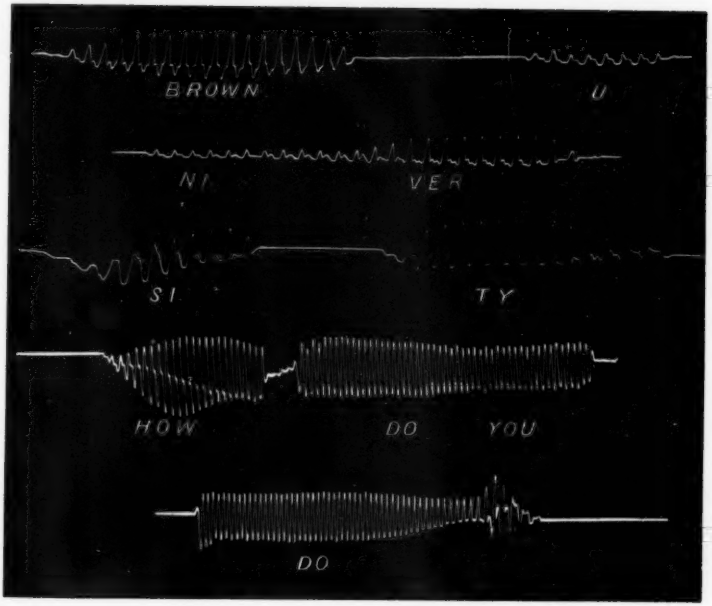
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the plates must be quite long when the velocity is great. I employ plates two feet in length, and find that velocities from 16 to 40 inches per second give good results. The action of the light is however inversely as the velocity. To compensate for this, the size of the circular opening admitting the light may be increased. This, of course, causes an enlargement of the luminous image, and apparently involves an injurious widening of the line traced, but, as observed by Dr. Stein in his experiments, the effect of velocity is to narrow the line photographed, since the maximum exposure is in that diameter of the circular image which lies in the line of motion. This is a great advantage, since a variation of velocity in the vibration is marked by the widening of the line, often more clearly than by the form of the curve.

I have employed the ordinary photographic process, not attempting to obtain special sensitiveness. The brightest sunlight is required, a slight haziness interfering seriously with the result. My heliostat employs two reflectors of ordinary looking-glass, and the loss of light is considerable.

To guide those who may wish to try this method I add the following measurements:

Diameter of circular opening	$\frac{3}{4}$ $\frac{7}{16}$ inches.*
Distance of mirror from circular opening	28 feet.
Distance of mirror from photographic plate	11½ inches.
Focal length of lens	9¼ inches.
Size of steel mirror	0·46x0·34 inches.
Weight of steel mirror	0·065 gram.

The question naturally arises whether the mirror may not so interfere with the vibrating disc as to destroy its articulation. The telephone gives a direct answer and banishes the doubt. The mirror was attached in the manner already described to the disc of a telephone, and the instrument showed itself still perfectly capable of 'sending,' and 'receiving,' without noticeable loss of clearness or quality.

Are *all* the audible elements of speech traceable in these records? in other words, is the record complete? I am not prepared as yet to answer this question definitely, but the following experiment leads me to doubt whether an affirmative answer can be given, while at the same time it illustrates in a striking manner the sensitiveness of the ear. The mirror was attached to the disc of a *receiving* telephone and a photograph taken from it while the instrument was talking audibly. The resulting record was almost a smooth line, showing but very slight indications of movement of the mirror. It would therefore, appear that there are distinctly audible elements, which

* Depending on velocity required, and on actinic intensity of the light.

are too minute to be recorded by this method. It is to be noted, however, that the width of the line traced where the vibrations are extremely small, is so great as to mask the curvature, so that the experiment just cited is not entirely fair.

The clearness and beauty of the curves obtained can hardly be appreciated without inspection of the originals. Their complexity and variety open a large field for investigation, and they seem to offer the means of analysis of articulate speech.

ART. VIII.—*Suggestions for a Telephonic Relay;* by Professor O. N. ROOD.

AFTER reading an account of the experiments of Mr. Hughes,* which may be regarded as an extension of the work of Edison, it occurred to me that the peculiar property of carbon, upon which they depend, might be utilized in the construction of a telephonic relay. I accordingly arranged three pieces of carbon in the form of an H, attaching the two outside pieces to the diaphragm of an ordinary telephone; this, with a battery, was destined to act as relay and re-transmitter. The first circuit included, then, a common telephone as sender, and the coil of the relay; the second included battery, vibrating carbon, and a common telephone used as a receiver. It was found that the vibrations of the pivots of the central piece of carbon were indeed able to modulate an electric current, so as to reproduce with somewhat diminished intensity sounds uttered in the sending telephone. Eight small vibrating carbons were now substituted for the single piece, and the reproduction was effected without loss of intensity or distinctness. The battery used with the relay consisted of eight small cells of zinc and carbon placed in diluted sulphuric acid only. For a relay to be efficient it is of course necessary that it should increase the loudness of the sounds so as to allow for electrical re-transmission to a more distant station; this can probably be effected, 1st, by making the telephonic relay of such dimensions that six or eight carbons can be placed approximately over the center of the iron diaphragm, and 2d, by using simultaneously several of these pieces of apparatus in the same circuit.

An arrangement like Hughes's microphone was also employed as sending instrument; an inverted coverless cigar box was used, on which I placed three vibrating carbons instead of a single one. The multiplication of the carbons was due to a suggestion of Dr. W. Gibbs, who at the time proposed various

* Nature, May 16, 1878.

forms of sending apparatus, all including the principle of multiple vibrating points or surfaces of contact. This simple apparatus was very sensitive, and reproduced with fidelity conversation in a low tone at a distance of more than thirty-five feet from the box; its performance suggested to me the multiplication of the carbons on the relay.

To the above I may add that when the electrical current used with the carbons is too powerful, a hissing, crackling sound is produced, which is from time to time varied by the introduction of a pure musical note, which often runs through considerable variation in pitch. This voltaic tone may be due to the repulsion exerted by the electrical current on itself, causing one of the carbon points to rise and fall with regularity in a manner analogous to the motion of the Trevelyan rocker, or it may be caused by rapid changes in temperature and hence in volume of the contact-surfaces. With fourteen small cups it occurred quite frequently.

Columbia College, June 10, 1878.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Microphone of Hughes.*—At the meeting of the Royal Society on May 9th, Professor Huxley presented a paper by D. E. Hughes of London, on the action of sonorous vibrations in varying the force of an electric current.* The results described were obtained in an attempt to investigate, by means of the telephone, the effect of sound vibrations on the electrical behavior of matter. Using a Daniell battery of three cells, with a telephone in circuit, the wire conductor was subjected to strain until it broke; no sound was heard except at the instant of rupture. It was then noticed that the sound could be reproduced on making and breaking the circuit with the broken ends of the wires, or even more simply by connecting the wires with two nails placed side by side, a third lying upon them at right angles breaking or lessening contact whenever subjected to jar, even by sound waves. Ten or twenty nails piled up log-hut fashion, increased the effect, and a piece of steel watch chain worked very well. Still better results were obtained by the use of a metallic powder in a glass tube, the instrument in this form being so sensitive as to reproduce articulate speech. All finely divided conductors which do not readily oxidize, such as platinum, mercury and carbon, or still better metallized carbon (willow charcoal heated to whiteness and plunged into mercury) may be used for the purpose, a glass tube filled with such substances, and provided with wires for insertion in a

* Engineering, xxv, 369, 384, May 10 and 17, 1878. Sci. Am. Suppl. v, 2024, June 8, 1878.

circuit, being called a "transmitter." Exposed to sound, even when quite inaudible to the unaided ear, the resistance of the transmitter varies in consequence of the vibration, thus varying the current strength and producing in the telephone a distinct noise. The slightest touch on the table where it is lying, the merest contact with a feather or a camel's hair brush, is distinctly heard in the receiver, and both instrumental and vocal sounds are transmitted with power. Acting on these facts, Hughes devised an instrument especially adapted for magnifying weak sounds, to which he gave the name microphone. It consists simply of a piece of gas carbon, an inch long, ¼ inch wide at the center, and ⅛ inch thick, pointed at the ends and supported vertically between two blocks of the same carbon which have small cavities hollowed out to receive it, the upper end being more blunt than the lower, and rounded. The weight of the upright piece is only just sufficient to make a feeble contact. With this form of transmitter the beating of the pulse, the tick of a watch, the tramp of a fly can thus be heard at least a hundred miles from the source of sound. In explanation of these facts, the author says: "It is quite evident that these effects are due to a difference of pressure at the different points of contact and that they are dependent for the perfection of action upon the number of these points of contact. They are not dependent upon any apparent difference in the bodies in contact but the same body in a state of minute subdivision is equally effective."

The results which have been obtained by Hughes as above described, are clearly anticipated by more than a year by those of Edison.* In January, 1877, while engaged in perfecting an articulating telephone, Edison made use of the fact discovered by him in 1873, that semi-conductors have the peculiar property of varying their resistance with pressure. To the center of a diaphragm was attached a spring faced with platinum, in front of which, and movable by an adjusting screw, was a small cylinder of graphite. This arrangement gave great volume of sound but its articulation was poor. After extensive experimenting, using the graphite mixed with various substances, lead peroxide, copper iodide, pulverized gas retort carbon, manganese peroxide, amorphous phosphorus, finely divided metals, many sulphides, tufts of silk fiber coated with metals by chemical means and pressed into disks, etc., he was led to adopt a disk made of the lampblack from petroleum smoke and to use it in the primary circuit of a small induction coil. This constitutes the carbon telephone, which, certainly for long circuits is the loudest transmitter known. In June, 1877,† he described a new form of relay based on the principle of varying resistance by pressure, using disks of carbon on the poles of the receiving electro-magnet, on which disks the armature rested. The coils of this magnet were in the primary circuit, the cores,

*The Speaking Telephone, Talking Phonograph and other novelties. By George B. Prescott. pp. 431, 8vo. New York, 1878. D. Appleton & Co.

†Journal of the Telegraph, x, 163, June, 1877.

disks and armature in the secondary. When a current passed through the magnet, the armature was attracted, compressed the carbon disk, diminished its resistance, and so increased the current strength in the secondary circuit. Since the diminution of the resistance is exactly as the pressure, the relay translated the varying current strength of the one circuit into a varying current strength in the other, of precisely similar character; thus for the first time making it possible to relay telephone currents. That the effects thus obtained by Edison are due simply to varying external contact, was first proved by C. B. Richards of Hartford in July, 1877. Placing a graphite cylinder between the jaws of a vise, platinum battery-contacts being provided at the ends, he found that the resistance of the cylinder to an electrical current diminished as the jaws of the vise were brought together, exactly as asserted. But if, in place of contacts at the ends, the connections were made by winding platinum wire round the cylinder just inside the ends, no variation of the galvanometer deflection was observed on increasing the pressure; thus proving conclusively that the phenomenon discovered and utilized by Edison depends upon the simple fact that a great variation in the resistance of a semi-conductor takes place on varying the surfaces of contact by pressure, the variation of resistance being directly as the pressure exerted.

It would seem sufficiently evident that the phenomena, of Hughes and Edison alike, are due to the varying resistance of an electrical circuit at the point or points of contact. The correctness of this explanation is proved by the increase of the effect with multiple contacts. This is accomplished by Hughes with finely divided materials such as metallized carbon, or metallic filings or carbon fragments in a glass tube; and by Edison by layers of silk covered with graphite, by several cylinders of graphite placed in a row, or by increasing the surface of his carbon button. The extreme sensitiveness of the Hughes apparatus is fully equalled by that of Edison, all the phenomena described with it being readily repeated with Edison's carbon transmitter, especially if a carbon button be used which has been worked over several times so as to be in a state of minute division. The tick, the brush, the fly tramp can all be heard with it. For purposes of practical telephony, however, this sensitiveness is a serious objection, and was overcome by Edison only after long experimenting. It is mainly a matter of adjustment of the contact pressure, as well in the carbon telephone as the microphone, the apparatus being the more sensitive the less the pressure. Moreover, the fact that Hughes transmits speech without the use of a diaphragm does not affect the question. Edison months ago replaced the vibrating diaphragm of his telephone by a plate of metal rigidly attached to the carbon, and serving to increase the loudness by increasing the surface on which the sound acts. This, however, is not at all necessary. It is easy to talk with the carbon transmitter of Edison, by projecting the sound waves directly against the carbon itself as in the microphone. Finally, Edison has utilized the varying resist-

ance of carbon contacts by pressure, in the construction of an apparatus by which minute differences of pressure may be measured, and has applied it to the construction of a thermometer, barometer, and hygrometer of extraordinary delicacy, and to the production of a rheostat of great simplicity. G. F. B.

2. *On the Boiling Point of Sulphuric acid of various strengths.*—Though the boiling point of the most concentrated sulphuric acid—containing 98·5 per cent H_2SO_4—was carefully fixed by Marignac at 338°, no determination of the boiling points of acid of less concentration has been made since Dalton. LUNGE has undertaken to redetermine accurately these boiling points by the following method: About 150 c.c. of the acid to be examined was placed in a flask having a long and wide neck and heated to boiling. In the flask the thermometer was so suspended by wires of platinum as to maintain a central position, the bulb being wholly immersed in the liquid. Since by loss of water the strength of the acid is increased, the boiling point must be determined at the beginning of ebullition. This the author takes to be the instant at which the stem of the thermometer is surrounded by transparent vapors, and a partial condensation takes place on the neck, the thermometer becoming at the same time stationary for from a quarter to half a minute. In this way, an accuracy of half a degree may be attained. The density of the acid was determined by direct weighing and reduced by Bineau's formula to 15°. The percentage of H_2SO_4 was obtained from this by interpolation in Kolb's tables below sixty-three, and in Bineau's above this percentage. Plotting the observed boiling points as ordinates and the percentages of H_2SO_4 as abscissas, a curve is obtained which is very nearly a parabola and by which the boiling points may be obtained for intermediate strengths.—*Ber. Berl. Chem. Ges.*, xi, 370, March, 1878. G. F. B.

3. *Substitution of Sulphur for Oxygen in the Fatty Series.*—In the formula $C_nH_{2n+1}COOH$, which represents the acids of the fatty series, the oxygen of the carboxyl group may be partly or wholly replaced by sulphur, giving rise to three series of bodies, $C_nH_{2n+1}CSOH$, $C_nH_{2n+1}COSH$, and $C_nH_{2n+1}CSSH$, the first two of which are isomers. The confusion in naming these bodies is avoided by adopting the suggestion of Wurtz in his Dictionnaire de Chimie, and prefixing *sulpho* to the name of the acid when the oxygen in the carboxyl is replaced by sulphur, as in the first formula above given, *thio* when the oxygen of the hydroxyl is thus replaced, and *thio-sulpho* when both suffer substitution. Only the second of these classes has been yet produced, thio-acetic, thio-propionic and thio-valeric acids having been studied. DUPRÉ has succeeded in producing a member of the first series, sulpho-propionic acid, by the action of sodium sulphydrate and hydrogen sulphide upon ethyl cyanide, the materials being placed in a flask with an inverted condenser, and heated on the water bath for five or six days. The flask contained two layers of liquid, the upper one of which was a solution of sodium sulphydrate.

On decanting this, an oily liquid remained, which on cooling became a crystalline mass; and this after purification gave on analysis the formula C_3H_5OSNa,H_2O. To establish the constitution of this body, nothing more is necessary than to convert the hydrate into the chloride, and see if the chloride contains sulphur; as this, of course, could not be the case if it is the hydroxyl oxygen which is replaced. For this purpose the sodium salt was treated with phosphoric oxychloride, and a chloride of sulphopropionyl $C_3H_5S.Cl$ was obtained, though in minute quantities. Sodium sulphopropionate, C_2H_4CSONa, is very soluble in water and gives with lead acetate a white precipitate permanent in the cold; which distinguishes the sulpho from the thio salt, its isomer, which blackens at once. The barium salt was also obtained.—*Bull. Soc. Ch.*, II, xxix, 303, April, 1878. G. F. B.

4. *On the Synthesis of Oxindol.*—The conception that isatic acid is orthoamidophenylglyoxalic acid and that isatin is its anhydride, was first enunciated by Kekulé in 1869, who announced his intention to prepare orthoamidophenylacetic acid, and from this by oxidation to produce isatin. BAEYER has now succeeded for the time in preparing orthoamidophenylacetic acid, and in showing its ready conversion into oxindol. That oxindol is really the anhydride of orthoamidophenylacetic acid was proved by Suida, who, at Baeyer's suggestion, examined the question whether, in the reduction of isatin to oxindol, one or two CO groups were attacked, and if only one whether it was that group which was attached to the benzene, or the other one. On analytical grounds, the formula $C_6H_4\begin{cases} CH_2CO \\ | \\ NH \end{cases}$ was established for oxindol, thus answering the problem. The synthesis of oxindol is extremely simple. Phenylacetic acid is nitrated by means of fuming nitric acid, producing nitrophenylacetic acid. This is reduced with tin and hydrochloric acid to amidophenylacetic acid. The acid liquid is neutralized with marble and boiled with precipitated barium carbonate. The isomeric amido-acids form barium salts, with the exception of the ortho-acid, which decomposes into its anhydride, and remains in the solution, from which the pure oxindol is extracted by ether. It fuses at 120°, yields indol when reduced with zinc dust, and yields the well characterized color reaction of nitrosoxindol with nitrous acid.—*Ber. Berl. Chem. Ges.*, xi, 582, April, 1878. G. F. B.

5. *On Aldehydines, a new Class of Bases.*—LADENBURG has given the name aldehydines to a class of basic bodies formed by the condensation of one molecule of an orthodiamine and two molecules of aldehyde, with the separation of two molecules of water. For the preparation of tolubenzaldehydine, a mixture of one molecule of ortho-toluyl-diamine and two molecules of benzaldehyde is heated to 140° in open vessels for eighteen hours. The resulting mass is dissolved in hot alcohol, and on cooling yellow crystals separate, which, dissolved in hot dilute hydrochloric acid, yield long colorless needles of the hydrochlorate of the new base. Decomposed by ammonia, the base itself is obtained, and

is purified by recrystallization from alcohol. It fuses at 195·5°, crystallizes in clear colorless monoclinic prisms, sublimes in small quantities, is insoluble in water, but soluble in alcohol and acetone, and in dilute acids. Its formula is $C_{21}H_{18}N_2$. Heated with ethyl iodide to 120°, yellow crystals of tolubenzaldehydine-ethyl iodide are obtained; and these treated with silver oxide, yield a strongly alkaline solution from which on evaporation an oil separated which could not be crystallized. Oxidized with permanganate, it gives dibenzenylamido-benzoic acid, $C_6H_3COOH(NC_7H_5)_2$. Hence, the author assigns to tolubenzaldehydine the probable rational formula $C_7H_6\begin{cases}NCC_6H_5\\ \times\\ NCC_6H_5\end{cases}$. Tolufurfuraldehydine, and tolusalicylaldehydine —to which he gives the special name azurine because of its magnificent blue fluorescence—are also described.—*Ber. Berl. Chem. Ges.*, xi, 590, April, 1878. G. F. B.

6. *On the Preparation and Properties of Invertin.*—Barth has investigated exhaustively the substance which is the inverting constituent of yeast, and which Donath called invertin. To prepare it, compressed yeast, freshly prepared, is coarsely pulverized, spread out in a capsule, and dried at a temperature not exceeding 40°, until it can be rubbed to a fine powder between the fingers. It is then heated on an air bath to 100° to 105° for six hours, mixed with water to a thin magma, allowed to stand for twelve hours at 40°, strained, and then filtered. The clear yellowish filtrate is poured into five or six times its volume of 95 per cent alcohol, by which a white flocculent precipitate is produced, which by strong agitation becomes granular, and may be easily filtered off. To free the ferment from albuminates—which this treatment with alcohol renders insoluble in water—the precipitate is freed from alcohol by pressure, digested in just sufficient water for solution, and filtered; the albuminates remain on the filter as a gelatinous mass. On pouring the filtrate into alcohol, the ferment is precipitated in the pure form. It is filtered off, washed with absolute alcohol at least ten times, the excess of alcohol expressed, and the precipitate dried in vacuo. The yield is about two grams from five hundred of yeast. Invertin thus obtained is a white powder, giving a clear yellowish-brown neutral solution with water, which, boiled with acetic acid and salt, is not rendered turbid, showing that it is neither an albuminate itself nor contains one as an impurity. Boiled with dilute copper solution and sodium hydrate, no violet color appears, showing the absence of peptones. No leucin could be detected on long boiling with sulphuric acid. On analysis it yielded 22 per cent of ash, consisting of potassium, calcium and magnesium phosphates. Calculating this out, it contained carbon 43·9 per cent, hydrogen 8·4 per cent, nitrogen 6·0 per cent, sulphur 0·63 and oxygen (by loss) 41·17 per cent. Experiments on the activity of invertin, using cane sugar solution, showed that it is dependent on the concentration of the sugar solution, is proportional to the quantity of the ferment

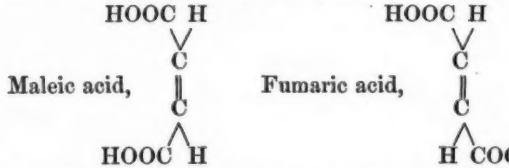
present, reaches its limit in about forty hours, and that one part of invertin produces 760 parts of inverted sugar as a maximum.—*Ber. Berl. Chem. Ges.*, xi, 474, March, 1878. G. F. B.

7. *On the occurrence of Allantoin and Hippuric acid in the Urine of the Dog.*—SALKOWSKI has confirmed fully the statement of Meissner that both allantoin and hippuric acid occur in the urine of the dog. In the attempts to dissolve the crystalline residue of the evaporation of the urine of a dog in cold water, he noticed that a not inconsiderable mass remained undissolved. By recrystallization from hot water, crystals of pure allantoin were obtained. The amount given was 0·8 gram from the urine of four days, the dog being fed on meat. The hippuric acid was detected in the urine of the four days' experimented with, when hungry, when fed on meat, and when the intestine was ligated. As a maximum it reached one one hundred and twenty-ninth of the urea. It was never entirely absent, even when no food or only purely animal food was given; and the ligation seemed to be without influence. —*Ber. Berl. Chem. Ges.*, xi, 500, March, 1878. G. F. B.

8. *On the Coloring Matter of the Shells of Birds' Eggs.*—The brilliant and remarkably permanent color of the eggs of many birds has led LIEBERMANN to the investigation of its cause. He finds that however widely different these colors are from each other, they are due essentially to but two coloring matters, one a blue or green substance, probably a biliary coloring matter, the other characterized by a remarkable absorption spectrum. These coloring matters are contained in the superficial layer of the shell, often in several thicknesses. When the shell is treated with dilute hydrochloric acid, the coloring matter separates in flocks, and by treatment with alcohol a strong solution may be obtained. With the eggs of gulls and plovers, an unsuccessful attempt was made to obtain the coloring matter pure. The colored alcoholic solution shows two sharp absorption bands, one on each side of the D line, when strongly acid. When alkaline, four weaker bands appear, none of which are coincident with the first.—*Ber. Berl. Chem. Ges.*, xi, 606, April, 1878. G. F. B.

9. *Chemistry in Space.* — Speculations on the forms of molecules and the arrangement of the atoms in space are generally as useless to the scientific world as they are entertaining to their authors, and are therefore almost exclusively confined to fanciful chemists, like J. G. McVickers, D.D., LL.D., who draw from their imaginations most beautiful and symmetrical pictures of molecules, which resemble nothing earthly unless those many-angled ornaments made of straw or perforated card-board so common in the windows of farmhouses. The pamphlet on "Chemistry in Space" recently published by Van't Hoff must not be confounded with these amusing but unprofitable examples of the so-called chemistry of the future, as its sole object is to establish a theoretical explanation of those cases of isomerism, usually called physical, and not accounted for by our present plane chemical formulas. Its importance is shown by a most complimentary preface written by Wislizenus for the German edition, and perhaps quite as well

by a violent criticism from the great chemical Ishmaelite, Kolbe, who never deigns to attack any but the most important theories. The principal points made by Van't Hoff may be stated briefly as follows: *First.* If the four affinities of an atom of carbon project from it toward the angles of a regular tetrahedron, and each of these affinities is satisfied by a different radical, two isomers are possible (instead of none as predicted by the same formula conceived as a plane figure) because there are two arrangements of these radicals which cannot be made to coincide by any change of position. One of these stands to the other in the same relation as that of any object to its image in a looking-glass. For example, one of the carbon atoms in laché acids is attached to four different radicals (CH_3, COOH, H, HO), and we find two laché acids accordingly, one from milk, the other from flesh, resembling each other in chemical relations most closely, but differing in physical properties. *Second.* In unsaturated compounds where two carbon atoms are united along one edge of the tetrahedra, two isomers are possible, if the two free affinities in each carbon atom are satisfied by different radicals; for instance in maleic and fumaric acids each carbon atom is attached to COOH and to H; if the two carboxyls are adjacent we have maleic acid, thus accounting for the ease with which its anhydride is formed, while in fumaric acid each carboxyl is adjacent to a hydrogen atom,



This is certainly a simple and probable explanation of this puzzling case of isomerism, which drove Fittig in his recent classical work on the unsaturated acids to the undesirable assumption of a bivalent carbonatom as the only explanation possible on the old theories. *Third.* The phenomena of circular polarization can be explained by a spiral arrangement of the different radicals attached to a carbonatom; according as this screw turns to the right or the left would the plane of polarization be deflected in one or the other direction; while two atoms with opposite spirals in the same molecule would give an inactive substance. By this hypothesis the different forms of tartaric acid and the differences between dextrose and levulose can be fully explained.

The limits of this notice, and the absence of figures, render it impossible to do justice to this extraordinary little pamphlet of Van't Hoff's, which will richly pay the trouble of reading, as there can be no doubt that it contains a large and important addition to our chemical theories, and marks out a great number of new lines for experimental work.* C. L. J.

* La Chimie dans l'Espace, J. H. Van't Hoff. Rotterdam, 1875. Translated by F. Hermann as Die Lagerung der Atome in Raume. Vieweg und Sohn. 1877.

10. *Studies in Spectrum Analysis;* by J. NORMAN LOCKYER, F.R.S. 258 pp. 8vo. New York (D. Appleton & Co.—International Scientific Series).—Professor Lockyer's name has been so long connected with the subject of spectrum analysis that a new work by him can hardly need commendation. The book commences with a theoretical explanation of sound-waves, and light-waves, and goes on to explain the methods of demonstrating spectrum phenomena. Other chapters are devoted to spectrum photography, the spectra of salts, dissociation, quantitative spectrum analysis, results of the study of the sun with the spectroscope, and other kindred subjects. The work is a collection of interesting essays written in a clear and simple style, with excellent illustrations, and embodying what is newest in this branch of science. Taken together, however, the subjects are somewhat wanting in connection.

II. GEOLOGY AND MINERALOGY.

1. *On Terrace Levels in Pennsylvania;* by Prof. J. P. LESLEY, Director of the Pennsylvania Geological Survey. Letter to J. D. Dana, dated Philadelphia, May 27, 1878.—In my preface to Prof. I. C. White's Report of Progress Q on Alleghany, Butler and Beaver Counties lying on the north side of Ohio river, in Western Pennsylvania, I have ventured to discuss the character of the terrace deposits along that river, and along the Monongahela river; not with any hope of solving one of our hard problems, but to place a provisional picture of the facts, thus far collected by Prof. Stevenson and Prof. White, before the attentive consideration of other gentlemen, engaged in the study of our surface deposits in other districts of the State. What opinions I ventured with much hesitation to express were not entirely approved of by Prof. Stevenson and Prof. White, who had the best right in the world to their view because so familiar with the field. My own opinions were based, however, not only on the phenomena exhibited there, but on a large body of facts exhibited in other parts of the State. And yet I hold them very lightly; for there is a great deal still to be learned before the order, extent and nature of the events of the Champlain period can be made out satisfactorily.

I drew the contour curve of 1,300 feet above tide around the sides of all the valleys of Western Pennsylvania, to see how a submergence of that magnitude would account for the terraces (or some of them) and for the distribution of the perched azoic blocks, confined geographically to the country west of the Beaver River and north of the Ohio; and I concluded that a submergence to that extent was probable; also, that the upper clay terraces represent the sloping plains of mud which during that submergence were deposited in the valleys, by ordinary deposit from the surrounding and intervening coal-measure high lands. I have (it is needless to say) always considered our whole topographical sculpture nearly accomplished and finished previous to the com-

mencement of this era of late and temporary submergence; and I am still unable to see any need for changing my old views. I still believe that the valleys have been refilled and are being reëxcavated; the terraces being only residual strips of Champlain clay left clinging to and upon older rock-terraces worn by the ancient erosion out of the hard and soft horizontal layers of the coal-measure mass.

I have just received a letter from Prof. White, announcing an important discovery bearing weightily upon the subject in question, made by Prof. Fontaine and himself about two miles from Morgantown in West Virginia. Here a broad level reach of country, called the Flats, extends from two to four miles back from the Monongahela river, toward the east, and south of the Pennsylvania State line. When critically examined, the whole area of the Flats was found to be "covered to an unknown depth with a very fine, tough, aluminous, creamy-white clay, containing immense numbers of vegetable remains in the most perfect state of preservation of which it is possible to conceive." Only a small collection has as yet been made and a few weeks must elapse before a sufficiently large collection can be made to decide the point how far the plant-forms differ from those of our present local flora.

The top of the deposit is about 300 feet above the river, which would make it more than 1,200 feet above tide. English geologists would be very apt to suggest a glacial dam at Pittsburgh to account for such deposits in the water basin of the Monongahela River. But there is no such short cut to an explanation of a phenomenon coëxtensive with half a dozen States of the Union.

Mr. White says the level of the Flats must be about the same with that of the pottery-clays so extensively worked at Greensboro and Geneva in Fayette County. He adds that on the "Second Terrace" (of Prof. Stevenson's series) below Morgantown, Mr. Keek in sinking a well 70 feet deep, passed through continuous silt and clays, and no rock. Prof. Stevenson's third Report of Progress (lettered KKK) is just coming from the press, and will be read with great interest by geologists who busy themselves with the more recent deposits.

2. *Cretaceous and Tertiary of Charleston, S. C.* — Lieutenant A. W. Vogdes, U. S. A., in a communication to the Charleston News and Courier for April 9th, states that in the Artesian boring at the Citadel, Charleston, the Cretaceous formation was reached at a depth of 950 feet, where occurred *Exogyra costata*, and other fossil shells, among them a new Chama, which he names *Chama Charlestonensis*. The *Exogyra* continued to be brought up to a depth of 1,825 feet, and with it at the lower depth were obtained *Ptychodus Mortoni*, *Gryphæa Pitcheri*, *Ostrea cretacea*, etc. The present depth of the well is 1,870 feet, and Lieutenant Vogdes believes that they are at work in the "second bed of the Cretaceous above the underlying granite, specimens of water-worn gravel and sand of decomposed granite

now being brought up;" and that the whole depth from the surface to the granite will probably be found to be 2,000 feet.

The overlying Eocene consists of the *Lower* Eocene or Buhrstone group, which has a thickness at Aiken of 200 feet and rests on the granite, and of 250 feet at Charleston; the Middle or Santee beds, which have a thickness of 300 feet at Charleston, and were formerly known as the Calcareous beds of the Charleston basin; and the *Upper*, which includes the Cooper and Ashley groups, about 300 feet thick in the Artesian boring. Next comes the later Tertiary, called by Lieutenant Vogdes Pliocene, which rests upon the Cooper group, and at Goose Creek is about 12 feet thick; it is stated to contain 45 per cent of recent shells.

3. *Yucatan Coral Reefs, and Cuba elevated Coral Rock.*—Prof. A. Agassiz, in his "Letter No. 1" on "Dredging operations of the U. S. Coast Survey, Schooner 'Blake,' during parts of January and February, 1878," describes the coral reefs of the Yucatan coast and land, and also the life of the sea bottom from there to the Florida Reefs. He states that the fauna of the Yucatan bank is identical with that of Florida. Alacran reef, on this bank, is an atoll, elliptical in form, about 14 miles long and 8 wide, with a depth of 1 to 6 fathoms inside, where are growing over the shallower parts "huge masses of *Astræa*, *Gorgonia*, *Meandrina*, and *Madrepora palmata*, which occasionally rise to the surface." The reef is steep to the eastward and slopes gradually to the westward. The structure is identical with that of the main Florida reef, and those of the northern coast of Cuba. In Cuba evidence of great elevation is seen in the existence of ancient coral reefs in the hills surrounding Havana and extending to Matanzas, these hills being 1200 feet high and consisting entirely of corals identical in species with those now living.

Large numbers of siliceous sponges were brought up on the Cuban coast, the *living Favosites*, "perhaps the most interesting coral ever dredged," together with many of the corals collected by Count Pourtalès on the rocky plateau south of the Florida reefs in 200 to 300 fathoms.

4. *The Richmond Bowlder Trains.*—These trains of bowlders, first made known by Dr. Stephen Reid, and described by Prof. Edward Hitchcock and later by Lyell, have been studied with care by E. R. Benton, and a description and map of them, with an excellent discussion of the facts, is contained in Bulletin Nos. 2–3, of vol. v, of the Museum of Comparative Zoology, Cambridge, 1878.

5. *Discovery of the Cleveland Shale in Delaware County, Ohio;* by L. E. Hicks, Prof. Nat. Sci., Denison University, Granville, Ohio. (Communicated.)—Among the subordinate questions connected with the Waverly group are those arising from the attempt to synchronise its sections in Southern and Central Ohio with that at Cleveland, upon which Newberry based his subdivisions. This section is as follows, beginning with the summit of the series:

Cuyahoga Shale	150to 250 feet thick.
Berea Grit	60 feet thick.
Bedford Shale	75 feet thick.
Cleveland Shale	21 to 60 feet thick.

Of these four members, so well and distinctively developed in Cuyahoga County, only the last uniformly retains its typical character in Central and Southern Ohio. It is everywhere a black bituminous shale containing scales, spines and teeth of fishes, and shells of a small species of *Lingula*. Not only is it uniform, but it is unique, both in respect to its fossils and its lithological characters. In the latter particular, it is true, it closely resembles the Huron shale (Devonian). *But the two never exist together in immediate contact.* In Northern Ohio they are separated by the Erie shale (Chemung); on the Ohio River by 147 feet of shales and sandstones of the Lower Waverly; and in Central Ohio by 75 to 100 feet of shales, siliceous limestone and sandstone.

On account of the great variations in lithological aspect of the other members, and the persistent uniformity of the Cleveland shale, the latter is the only reliable guide in determining the relations of associated strata. I have just made the discovery that an unmistakable outcrop of Cleveland shale exists two miles east of Sunbury in Delaware County, Southern Ohio, on the land of Horace Whitney. It lies *above* the calcareous sandrock of the Sunbury quarries, which Prof. N. H. Winchell, a special assistant on the Ohio geological survey, identified as *Berea grit.* My discovery *demonstrates* the incorrectness of that identification, and raises a strong presumption, amounting almost to a certainty, that he was equally wrong in respect to his Berea grit in Morrow and Crawford counties. I risk the prediction that the Cleveland shale will yet be found to the *east* of the supposed Berea at Mt. Gilead, Iberia and Leesville.

6. *Jurassic fossils in the Coast Range of British Columbia.*—Mr. J. F. Whiteaves has described the Jurassic fossils collected by Mr. G. M. Dawson, mostly from the vicinity of Iltasyouco River, a tributary of Salmon River, and Sigutlat Lake. The author concludes that nine of the twenty-eight species are identical with those of Jurassic rocks of Dakota described by Meek, namely: *Gryphæa calceola* var. *Nebrascensis*, *Camptonectes extenuatus*, *Eumicrotis curta*, *Modiola* (*Volsella*) *formosa*, *M. pertenuis*, *Grammatodon inornatus*, *Astarte fragilis*, *Pleuromya subelliptica*, *Planorbis veternus.* The other species include *Lima duplicata* Sowerby, *Stephanoceras Humphreysianum* Sowerby, *Pleuromya unioides* Rœmer, *Astarte ventricosa* Meek, a species described from Jurassic rocks of Nevada, *Trigonia Dawsoni* Whiteaves, also identical with a Nevada species, a *Belemnites*, etc. The species are stated to be probably either Liassic or Lower Oolite. Mr. Whiteaves remarks that the Upper Trias is known to extend from Mexico to British Columbia, and that *Monotis subcircularis* of Gabb has been found recently in the northern part of Vancouver Island, on Peace River on the mainland, and on

Upper Pine River east of the mountains; and that the Jurassic and Cretaceous seas were probably equally extensive; that some Texas Cretaceous species have been found in deposits of the same age on Peace River and on Vancouver Island; that during the Mesozoic there was no Rocky Mountain barrier separating the species east from those west.

7. *Thesaurus Devonico-Carboniferus; The Flora and Fauna of the Devonian and Carboniferous Periods*, with large Addenda (from recent acquisitions); by JOHN J. BIGSBY, M.D., F.R.S., F.G.S. 448 pp. 4to. London, 1878. (J. Van Voorst.)—Ten years have passed since the publication of the *Thesaurus Siluricus* by Dr. Bigsby; and now has appeared a volume still larger, and equally elaborate and complete, on the Devonian and Carboniferous Periods. Like the former work, it gives tables of the names of all known species of fossil plants and animals from the rocks of the formations under consideration, and these tables are so constructed as to exhibit the horizons of the species, their recurrences, localities, references to the places where described, and the synonymy of genera and species. In addition, the author lays down his deductions from a survey of the facts, describes sections of the Devonian and Carboniferous in Great Britain, various countries of Europe, and in other parts of the world; gives lists of the fossils of these countries, thirty in number, and a catalogue of the works and memoirs on the subject. The volume is hence most truly a "thesaurus," and will be so found by all American as well as other geologists. The author observes that the number of Silurian species known at the time of publication of his work (February, 1878) is about 9500, of Devonian 5600, of Carboniferous 8700.

Dr. Bigsby spent five summers in traveling through the Canadas, east and west, together with the State of New York and the States bordering on the Great Lakes, and the country northward to Hudson's Bay, and thus has had personal acquaintance with the older American rocks and their fossils, and also with many American geologists.

III. BOTANY AND ZOOLOGY.

1. *The Native Flowers and Ferns of the United States;* by THOMAS MEEHAN. Illustrated by chromo-lithographs. Boston: L. Prang & Co. Parts I and II, not dated, but issued in May, 1878. Each part with 4 plates and 16 pages of letter-press. Imp. 8vo. Published at 50 cents each.—From the title this work might be thought to be a combination of Isaac Sprague's Wild Flowers of America and Professor Eaton's Ferns of North America. But its aim is somewhat different. There is no attempt to rival the exquisiteness of these, and the size is smaller. The endeavor here is to give good figures at a wonderfully low price. In the work on Ferns we have three plates (many with two species) for a dollar; here we have four for half the money. And the publishers, the

well known firm of Prang and Company, have certainly done their work well, considering the price, which must increase rapidly with the number of stones used and the number of color-impressions necessary to give the right effect. If we judged the draughtsman from his representation of *Anemone nemorosa* we could highly commend his work. If we took those of *Gelsemium* and *Aquilegia chrysantha* as the type, we could do no such thing. But we have an idea that the artist, Mr. Alois Lunzer, is not to be judged by these, and that his capacity for improvement, already manifest, has not reached its limits. It costs the lithographers no more to work from first-class drawings, than from those of mediocre quality; and if they can afford to carry on the work at all at the present rate, it will doubtless be very popular; for it appeals to a large class, and supplies a felt want. It is not the scientific botanist who is addressed, so much as the numerous array of flower-lovers, who wish to identify the plants they cultivate or observe, and that in the readiest and to them the chief practicable way, namely, by a plate or picture.

The letter-press is suited to the plates by its equally popular character and aim; but Mr. Meehan brings in a good deal of botanical lore and some philosophical disquisition, for which he has a remarkable aptitude. He has well proved his capacity for such an enterprise as this; but the rate at which it is to proceed, calling for sixteen pages every fortnight, may task the powers of the most energetic. In the rapid and discursive writing it calls for, statements will often fall from the pen which need qualification or discrimination, such as that on the first page, in which Tournefort is joined with Linnæus as having "made botany simple by reducing the Latin names given to each plant to two, the generic and the specific." A semi-anachronism. On p. 20, describing the blossom of the Blue Violet, and referring to the spur-like appendages to the lower anthers, Mr. Meehan writes:

"Some have contended that the projection is used as a lever, which, on being raised by an insect in search of nectar, causes pollen to be thrown on the insect's back, and the pollen is thus taken to another, thus cross-fertilizing it; but as in this Violet the spur-membrane is so closely fitted to the 'lever' that it cannot work, it shows how wholly imaginary these speculations are." What is included in "these speculations" is not further explained. But this particular speculation is so out of keeping with the obvious facts that we are should think it not only "imaginary" but till now unimagined. Sprengel's speculations upon the relations of insects to the violet, as reproduced by Lubbock, contain nothing of this sort. His conjectures had the merit of being founded on genuine observations, have been in great part confirmed, and ought not to be set aside by silently coupling them with an absurd and "wholly imaginary" one.

Our criticism of details like these must be taken as expressive of our earnest desire that a work like this, which seems likely to succeed, and which has our best wishes, should be as free as possi-

ble from flaws and short-comings. High art and exact science we do not expect; but completeness and substantial correctness may be looked for. A. G.

2. *Monographia Metzgeriæ;* auctore S. O. LINDBERG. — A pamphlet of 48 pages and two plates (leaf-sections), 8vo; gives eleven species to this genus of *Hepaticæ*, besides two of Mr. Austin's admitted as subspecies. Separate issue of a paper in the Proceedings of the Fennian Society at Helsingfors. A. G.

3. *Bryineæ Acrocarpæ: Utkart till en Naturlig grupperung af Europas Bladmossor med toppoistande Frukt.* Program af S. O. LINDBERG. Helsingfors, 1878.—A sketch of a new and natural arrangement of the Acrocarpic Mosses. A. G.

4. *Ferns of Trinidad.* — Mr. AUGUSTUS FENDLER, who began his botanical work as a collector, thirty years ago, when he first explored the region of Santa Fe, New Mexico, and made an admirable and well known collection, and who afterwards made still larger collections in Venezuela, is now resident in the Island of Trinidad. He proposes to collect all the species of Ferns and fern-like plants of that rich tropical island, and to distribute them in sets. The first installment, containing complete and handsome specimens of 78 species, is just received in excellent condition. The price is $7.50 for a set. Application may be made to the Curator of Harvard University Herbarium, Cambridge, Mass. The species will speedily be named by Professor Eaton, of Yale College, and a printed list furnished. A. G.

5. *Flora Brasiliensis*, Fasc. 73, issued in October last, contains the *Lythraceæ*, by Koehne, of Berlin, a new collaborator, and apparently an able one. Under the genus *Cuphea*, of which the Brazilian empire contains seventy-four species, the editor has given a synopsis of all the known species, which will be very useful, as many are in cultivation. Dr. Koehne is probably quite right in his opinion that *Lythrum Hyssopifolia* is not indigenous to North America; also that two or three species are to be distinguished among the plants referred to *Lythrum alatum* Pursh, in Torrey and Gray's Flora of North America, and other works. He follows Hiern in restoring the genus *Rotala*, which includes *Ameletia*, *Suffrenia*, etc., and extends it to take in *Hydrolythrum* and *Rhyacophila* (*Quartinia*) also. Upon the propriety of this we are not ready to pronounce; but we are confident that the separation from *Ammania* ought not to be made simply on the difference in the dehiscence of the capsule and the number of flowers in the axils, thus throwing our two common United States species into different genera. Nor has *Ammania humilis* Michx., a cartilaginous capsule; it is really membranaceous and thin; but the nearly regular opening at the summit by short valves, instead of irregular lateral bursting, well distinguishes the species from the *A. latifolia*. As to the latter species, it still appears most probable that it includes both a form with subsessile stigma and prevailingly apetalous (*A. latifolia* of the Fl. Bras., *A. lingulata* Griseb, etc.,) and one with longer style (*A. sanguin-*

olenta Swartz, etc.,) which is usually petaliferous. It is to *A. arenaria* HBK. (which, as Koehne remarks, all subsequent botanists overlooked) that *A. Wrightii* Gray, belongs, and apparently *A. longipes* of Wright also. Fasc. 74 does not invite particular remark. It has the *Humiriaceæ* and *Lineæ* by Dr. I. Urban, also a new hand; and *Oxalidaeæ*, *Geraniaceæ*, and *Vivianiaceæ*, by Dr. A. Progel. The key to the 108 Brazilian species of *Oxalis* comprises also additional species of the adjacent regions. And a new genus of two species, allied to *Averrhoa*, is dedicated to Dr. Eichler, the excellent editor of this Flora. This fascicle is dated December, 1877; so that the present genus has priority over D. Hartog's *Eichleria*, which is perhaps a better marked genus. A. G.

6. *A Monograph of the Genus Lilium;* by HENRY JOHN ELWES, F.L.S., F.Z.S. Illustrated by W. H. Fitch., F.L.S. Folio. —Four parts of this truly magnificent contribution to Horticultural Botany have reached us. Mr. Elwes has long been known as a most successful and enthusiastic cultivator of lilies and other bulbous plants, and his collection of them is one of the most complete in existence. Not only has he been a most assiduous and enterprising collector of living plants, but he has known how to turn his collections to the best use, and is doing for *Lilium* what might, with equal advantage, be done for *Iris*, *Crocus* and *Gladiolus*, genera in which the limitation of species is attended with much confusion and difficulty. In *Lilium*, particularly, this difficulty has been largely increased by the fact that lilies have, for centuries, been favorite garden plants, and that many species have become so changed by long cultivation that it has been impossible to refer some existing forms to wild types without a thorough study of the whole genus, including all garden forms as well as their wild originals. This Mr. Elwes has undertaken, and his monograph will be found an indispensable aid to a better understanding of the genus.

Of the thirty-two plates, which have already appeared, six are devoted to North American species, those figured being *Lilium superbum; L. parvum* of Kellogg, which is rightly considered a species, and not a western form of *L. Canadense*, to which other European botanists have referred it; *L. pardalinum*, the figure very well representing Kellogg's typical plant, and not a variety, as Mr. Elwes supposes (but the synonyms as given for this species will require some further revision); *L. Humboldti*, a magnificent plate of one of the most distinct and beautiful of North American lilies; *L. Catesbœi; L. Philadelphicum*, and *L. Carolinianum*, which is considered as a species distinct from *L. superbum*, a view which is not shared by American botanists, whose previous opinion of this plant must be rather confirmed than otherwise by Mr. Fitch's beautiful drawing, which clearly represents a small form of *L. superbum*. Mr. Elwes notices as a curious fact " that all the American lilies, though varying remarkably among themselves, differ entirely in their bulb-structure from those of Europe and Asia, and the same peculiarity is noticeable

among the American species of *Fritillaria*, which, as far as we know them, have bulbs of small white and granular scales, loosely attached to a solid central axis from which the stem springs. Of all the Old World Lilies and Fritillaries, only two, namely, *Lilium avenaceum* and *Fritillaria Kamtschatkensis*, resemble their American congeners in the formation of their bulbs, and both of these are restricted in their geographical limits to the shores of Northeastern Asia, which have many affinities, both botanical and zoological, with the Pacific coast of North America." Each plate is accompanied by two or three pages of letter-press, containing a technical description of the species with a list of synonyms and references to other figures, as well as all available information in regard to its native habitat and mode of growth: also the history of its introduction into cultivation, and full cultural directions, derived from the author's own experience, and from that of the most successful lily growers of Europe. When completed the work will contain forty-eight colored plates, to which is to be joined an introductory chapter, containing wood-cuts of bulbs and other details, and a map showing the geographical distribution of the genus. C. S. S.

7. *Beiträge zur Keimungsgeschichte der Schizæaceen.* Dr. H. BAUKE. Extract from Pringsheim's Jahrbücher, vol. xi, 1878.—But little now remains to be studied with regard to the formation of the prothalus in the different suborders of Ferns. Not to speak of the numerous works on the development of the *Polypodiaceæ*, we have had within the last few years an account of the development of the genera *Osmunda* and *Ceratopteris* by Kny, and we noticed in the number of this Journal for March a paper by Gœbel, on the prothallus of *Gymnogramme leptophylla*. Junczewski and Rostafinski gave a description of the prothallus of Hymenophyllum in the Proceedings of the Cherbourg Society. In vol. x, of Pringsheim's Jahrbucher, Dr. Bauke gave an account of the prothallus of the *Cyatheaceæ* as compared with that of the other ferns, and that article is now supplemented by one on the germination of the *Schizæaceæ*. Dr. Bauke studied the germination in several species of *Aneimia* and in *Mohria Caffrorum*. He differs from Burch who has recently studied the development of the prothallus in *Aneimia* in several respects, and he does not consider that what Burch calls the "pousse latérale normale" is in any sense a lateral shoot, but simply that the formation of the cushion, in which the archegonia are produced, is in this case on the lateral margin of the prothallus rather than at the central sinus, as in the *Polypodiaceæ*. Bauke states that, although in general the prothallus of the *Schizæaceæ* differs from that of the *Polypodiaceæ*, yet there are numerous variations which connect the two suborders. W. G. F.

8. *Ueber die Aschenkrankheit und Blattflechenkrankheit der Citronenbäume;* by FELIX VON THUMEN.—The pamphlet bearing the present title is the latest contribution from the Experimental Station for the Culture of the Grape and Fruit at Klasterrænberg,

near Vienna. The botanist of the Station, Baron von Thümen, gives an account in Italian of two fungi, *Apiasporium citre* and *Sphærella gibelliana* which cause disease in the leaves of lemon trees. Another publication of interest is the list of fungi which are found on grape vines, of which the number of species is said to be 224. It must be remarked, however, that many of the species are not peculiar to the vine. W. G. F.

9. *Bulletin of the United States Geological and Geographical Survey of the Territories.* Vol. IV, No. 2. Department of the Interior.—This number of the Bulletin contains the following papers: The Geographical Distribution of Mammals considered in relation to the principal ontological regions of the earth, and the laws that govern the distribution of animal life, by J. A. Allen. Descriptions of new extinct Vertebrates from the Upper Tertiary and Dakota formations, by E. D. Cope. Catalogue of the Fishes of the fresh waters of North America, by D. S. Jordan. Description of a fossil bird from Colorado, by J. A. Allen (see page 382, vol. xv, of this Journal). Coleoptera of the Alpine region of the Rocky Mts., by J. L. LeConte. Orthoptera of Dakota and Montana, by C. Thomas. Hemiptera of Dakota and Montana, by P. R. Uhler. Lepidoptera of Montana, by W. H. Edwards. Fossil insects from the Tertiary of Colorado and Wyoming, by S. H. Scudder. These fossils insects are a few out of a large number of species which Mr. Scudder has under examination. He remarks that those from the Florissant Shales of Colorado indicate strikingly a tropical relation. A fossil butterfly, which he calls *Prodryas Persiphone*, is wonderfully perfect, the wings expanded as if in readiness for the cabinet, and even the form of the scales are distinguishable under the microscope.

IV. Astronomy.

1. *Observations of Comets made at the Sheffield Observatory of Yale College;* by H. A. Hazen and W. Beebe, with the ring micrometer of the $8\frac{3}{4}$ inch refractor. (Latitude of observatory= 41° 18′ 35″; longitude=16^m $30^s{\cdot}0$ E. of Washington.)—All the observations upon which the following results are based were made with a power of 60. The ring-micrometer is one constructed by Professor Lyman, and consists of several concentric rings. Of these, only the two smallest were used; and of the two, one or the other was sometimes omitted, if observation was thereby facilitated. A complete transit across one ring, comprising two ingresses and two egresses of each body, is considered as one comparison. In estimating the weights, an observation derived from six comparisons under fair conditions is assigned a weight of 2. This does not take into account, in case of comet *c*, the liability to error, arising from the fact that the comet exhibited no defined nucleus, nor has it any reference to the reliability of the catalogue from which a star's place is derived.

Comet b, 1877, (*Winnickey.*)

1877. New Haven m. t.	Comet—s. $\Delta\alpha$	Comet—s. $\Delta\delta$	Apparent α	log. Par. × Δ	Apparent δ	log. Par. × Δ	Comp. Star.	No. of Comparisons.	Weight of obs.
	m s	′ ″	h m s		° ′ ″				
May 3, 9 59 48·	+ 3 8·53	+ 10′27·″3	23 19 2·23	·7581*m*	+64° 14′35·″0	·9080	*a*	4	1
" 4, 8 53 22·	— 3 52·19	+ 6 18·6	23 26 24·82	·1350*m*	66 17 5·3	·9254	*r*	8	2
" 24, 13 44 17·	— 1 46·26	+ 2 29·5	8 13 0·49	1·0109	68 37 6·4	·8601	*b*	11	2
" " 14 42 20·	— 1 27·78	+ 0 34·3	8 13 19·97	·7891	68 35 11·2	·9006	*b*	4	1
" 28, 8 58 17·	— 2 25·70	— 4 3·2	8 36 7·77	1·1550	63 42 32·4	9·8857	*c*	8	2
" " 10 15 8·	— 2 11·20	— 7 56·7	8 36 22·27	1·1751	63 38 38·9	·4399	*c*	7	2
" 29, 8 55 24·	— 2 36·20	+ 5 41·6	8 40 38·61	1·1352	62 31 7·0	9·9116	*d*	9	3
June 1, 10 26 48·	— 0 26·42	+ 4 45·9	8 51 52·49	1·1105	59 5 0·6	·5367	*e*	12	3
" 2, 10 41 59·	+ 0 23·46	+ 11 55·0	8 54 56·23	1·0949	58 1 14·3	·6935	*f*	9	3
" 8, 9 24 59·	+ 0 57·45	— 6 1·3					*s*	12	3
" 14, 9 32 35·	— 1 49·40	— 1 23·6	9 19 1·67	·9939	47 42 26·0	·5621	*h*	6	1
" " 10 4 44·	— 1 47·44	— 2 28·8	9 19 3·63	·9930	47 41 20·8	·6373	*h*	8	1
" 16, 10 22 2·	+ 1 14·32	+ 8 43·9	9 21 42·80	·9759	46 17 15·8	·6901	*i*	11	2
" " 11 34 1·	— 1 17·29	+ 11 53·9	9 21 54·71	·9265	46 15 27·2	·8016	*k*	9	2
" 20, 9 46 50·	+ 1 41·29	— 5 47·5	9 26 51·55	·9564	43 45 30·8	·7042	*l*	8	1
" " 10 11 36·	+ 1 42·03	— 6 24·2	9 26 52·29	·9464	43 44 55·1	·7396	*l*	8	2
" 22, 10 56 35·	— 1 46·32	— 4 10·4	9 29 12·20	·9184	42 33 8·2	·6840	*m*	8	2
" 29, 9 29 0·	+ 1 32·90	+ 0 5·7	9 36 21·31	·9288	38 54 58·9	·6999	*n*	12	2
July 4, 9 31 9·	— 2 1·84	+ 11 41·6	9 40 58·46	·9105	36 38 32·4	·7344	*o*	7	1
" " 10 7 46·	— 2 0·91	+ 10 56·7	9 40 59·39	·8863	36 37 51·5	·7829	*o*	3	½
" 12, 9 29 38·	— 3 16·09	+ 7 56·0	9 47 42·04	·8272	33 29 7·3	·8353	*p*	8	1

Mean place of comparison stars for 1877·0, ***with reductions to date of observations.***

					α	δ
		h	m	s	h m s	s	° ′ ″	″
a=Oeltz. Arg. N.Z.	(*a* 1842,	23	14	26·69)	23 15 55·60	−1·90	64 4 17·0	− 9·3
b=Fedorenko	(*a* 1790,	8	6	7·32)	8 14 45·92	+1·83	68 34 21·4	+15·5
c=Rümker	2631,				8 38 31·58	+1·89	63 46 21·8	+13·8
d=Groombridge	1472,				8 43 12·92	+1·89	62 25 12·0	+13·4
e=Oeltz. Arg. N.Z.	(*a* 1842,	8	49	32·20)	8 52 17·07	+1·84	59 0 2·6	+12·1
f= " "	(*a* 1842,	8	51	50·19)	8 54 30·97	+1·80	57 49 7·5	+11·8
h= " "	(*a* 1842,	9	18	28·56)	9 20 49·32	+1·75	47 43 38·9	+10·7

Comet c, 1877, (*Swift.*)

1877. New Haven m. t.	Comet—s. $\Delta\alpha$	Comet—s. $\Delta\delta$	Apparent α	log. Par. $\times\Delta$	Apparent δ	log. Par. $\times\Delta$	Comp. Star.	No. of Comparisons.	Weight of obs.
	m s	″	h m s		° ′ ″				
Apr. 12, 9 2	−9 4·4	− 8′ 48·″	0 53 23·4	·7986	+53°56′ 5·″	·8901	*a*	3	1
" 22, 16 1	5· +3 10·39	−16 55·2	2 29 23·90	·7304	60 16 57·0	·8129	*b*	5	2
May 2, 10 30	31· +2 44·32	+10 23·2					*c*	6	2
" 3, 8 34	48· −2 39·92	+15 48·0	4 49 48·56	1·1243	60 31 39·3	·5501	*d*	7	2
" 4, 9 47	2· −3 18·43	− 0 10·0	5 3 11·63	1·0848	60 2 56·9	·7211	*e*	11	3
" 6, 13 54	32· −6 40·	+ 4 32·	5 29 42·30	·2818	58 48 38·9	·9368	*f*	8	2
" 12, 12 15	24· −3 2·9	−10 47·	6 30 10·60	·8858	54 3 5·6	·8979	*g*	8	2
June 1, 9 36	9· −0 25·90	− 3 6·4	8 19 57·12	·9134	33 53 6·6	·6851	*h*	6	1
" 1, 9 36	9· −0 34·59	−12 38·5	8 20 0·17	·9134	33 52 54·5	·6851	*i*	6	1
" 2, 9 57	57· +1 53·55	−13 44·3	8 23 23·99	·8969	32 52 18·5	·7160	*k*	4	1

Place of comparison stars.

	α	δ	log. Par. $\times\Delta$
	h m s	° ′ ″	
a=Lalande 2000,	1 2 28·33 − 1·53	54 4 50″6 + 2″6	
b=Bonn obs., vol. vi,	2 26 15·09 − 1·58	60 34 0·8 + 8·6	
c= " " " v, zone 60, No. 834, position only approximate.			
d=Wash. 26 year cat. 2107, Rümker 1332,	4 52 26·86 − ·28	60 15 35·9 + 15·4 assumed $\frac{L+2W}{3}$	
e=Lalande 9739	5 6 30·19 − ·13	60 2 51·5 + 15·4	
f= " 10687	5 36 22·10 + ·20	58 43 50·9 + 16·0	
g=Bonn obs., vol. vi, p. 268	6 33 12·72 + ·78	54 13 37·6 + 15·0	
h=Lalande 16548-9	8 20 21·76 + 1·26	33 56 5·9 + 7·1	
i= " 16557	8 20 33·52 + 1·24	34 5 25·8 + 7·2	
k= " 16592	8 21 29·20 + 1·24	33 5 56·0 + 6·8	

	α	δ		
	h m s	° ′ ″		
i=Washington 26 year cat.	39·50	9 20 35·86 + 1·63	46 8 24·″6 +	7·″3
k=Radcliffe 2357,		9 25 10·35 + 1·62	46 3 26·1 +	7·2
l=Lalande 18693,		9 25 8·68 + 1·58	43 51 13·1 +	6·2
m=Weisse (2) IX 644,		9 31 56·94 + 1·58	42 37 12·7 +	5·9
n= " " 707,		9 34 46·89 + 1·52	38 54 49·9 +	3·3
o=Lalande 19244,		9 42 58·80 + 1·50	36 26 48·6 +	3·2
p=Weisse (2) IX 1053, Lal. 19469		9 50 56·64 + 1·49	33 37 2·3 +	1·0
			assumed	$\frac{L+2W}{3}$
s=Bonn obs. I. zone 52 1376, position only approximate.				
r=Rümker 11396,		23 30 18·91 − 1·91	66 10 56·0 +	9·3

Comet e, 1877, (*Coggia.*)

1877. New Haven m. t.	Comet—s. $\Delta\alpha$	Comet—s. $\Delta\delta$	Apparent α	log. Par. × Δ	Apparent δ	log. Par. × Δ	Comp. Star.	No. of Comparisons.	Weight of obs.
	m s	″	h m s		° ′ ″				
Oct. 2, 13 38 2·	+2 33·60	+25′ 21·″6	8 19 1·59	·9569*n*	+42° 49′ 8·″6	·6170	*a*	3	1

Place of comparison stars.

	α h m s	δ ° ′ ″
a=Wash. 26 year cat. 3370	8 16 22·77 + 5·22	42 23 56·0 — 9·0

Comet f, 1877, (*Tempel.*)

Oct.	5, 10 30 40·	+1 12·94	+ 2′ 10·″8	23 39 6·38	9·3727*n*	−13° 49′ 43·3	·8608	*a*	11	3
"	6, 9 23 30·	+2 16·94	+ 6 41·2	23 36 45·36	9·6396*n*	−14 47 1·5	·8656	*b*	11	3
"	7, 9 48 24·	+4 5·86	+14 35·7	23 32 34·92	·0430*n*	−15 40 22·3	·8689	*c*	12	3
"	9, 9 25 16·	−2 34·80	− 5 6·8	23 26 32·66	9·6305	−17 20 25·0	·8280	*d*	8	2
"	11, 7 41 24·	+2 21·98	− 2 35·2	23 21 11·19	·5967*n*	−18 48 30·6	·8897	*e*	6	2
"	12, 10 18 19·	+0 36·32	−13 16·4	23 15 8·93	9·9682	−19 25 53·3	·8764	*f*	6	1

a=Weisse XXIII 744	23 37 49·23 + 4·21	−13 52 17·8 + 23·7
b=Oeltz. Argel. I. 22963	23 33 24·19 + 4·23	−14 54 5·9 + 23·2
c=Rümker 11352	23 28 24·82 + 4·24	−15 55 20·6 + 22·6
d=Lalande 46199	23 29 3·21 + 4·25	−17 15 40·4 + 22·2
e= " 45838	23 18 44·95 + 4·26	−18 46 16·3 + 21·0
f= " 45704	23 14 26·33 + 4·28	−19 12 57·4 + 20·5

V. Miscellaneous Scientific Intelligence.

1. *Japanese Earthquakes.*—An interesting historical paper upon "Destructive Earthquakes in Japan," (27 pp.) was read before the Asiatic Society of Japan, March 23d, 1878, by I. Z. Hattori, Esq. (Rutgers Coll.), of the University of Tokio.

It includes notices, drawn from native sources, of 149 destructive earthquakes, distributed as follows:

1 in	5th century.	7 in	13th century.
1 "	6th "	8 "	14th "
7 "	7th "	15 "	15th "
7 "	8th "	8 "	16th "
28 "	9th "	15 "	17th "
11 "	10th "	13 "	18th "
10 "	11th "	16 "	19th "
1 "	12th "		

Arranging the recorded shocks according to the seasons the author says: "If we take the 11th, 12th, and 1st months of the Japanese old calendar as cold months, 5th, 6th and 7th as hot, and all the others as mild, then during the fifteen centuries, twenty-eight great earthquakes have occurred in the cold months, forty-seven in the hot, and seventy-two in the mild, or in other words, seventy-five in the extreme seasons and seventy-two in the mild, the difference being only three." He also gives a curious description of an early Chinese seismograph "invented by Choko in the first year of Yoka, (132 A. D.)" It is quoted from the Life of Choko in Gokwanjo (History of Kwan), and is as follows.

"The seismograph consisted of a copper vessel, whose diameter was eight *shaker* or feet, and whose convex cover was ornamented with characters, mountain turtles, birds and beasts. In this vessel there was one main piston in the middle with its eight branches, wires and springs. On the outside of this vessel were eight dragon heads, each of them having a copper ball in its full-opened mouth. Under each of the dragon heads there was a frog looking upwards with its mouth fully opened. The wire works and springs were very skillfully arranged in the vessel, but the cover was very closely fitted, and they could not be seen. Whenever the earth shook, one of the dragons dropped the ball, the frog underneath received it in its mouth, and produced a sound. By this means the direction of the shocks was ascertained. Once one of the dragons dropped its ball, but no person near it perceived any shock, and all the learned men of the capital doubted the trustworthiness of the machine; but after a few days a mail arrived from Rosei and reported the occurrence of an earthquake there."

The different Japanese beliefs or superstitions about the cause of earthquakes are also described. C. G. R.

2. *American Association at St. Louis, Aug.* 21.—The headquarters of the Association at St. Louis will be at the Lindell Hotel on the Monday and Tuesday preceding the meeting, and afterward at Armory Hall. All members planning to attend the meeting are requested to communicate at once with Prof. J. K. Rees, who is Secretary of the Local Committee. Communications relative to membership, papers, and payments of assessments should be made to the Permanent Secretary, F. W. Putnam, whose address is Salem, Mass., until Wednesday, Aug. 14, and after that time, St. Louis, Missouri. The first meeting of the Standing Committee will be at the Lindell Hotel, on Wednesday, Aug. 20, at 3 P. M.

Arrangements for half fare on various railroads can be learned of by addressing Wm. Taussig, St. Louis.

3. *Catalogue of Scientific Serial Publications.*—An extended catalogue of Scientific Serials is soon to be issued under the auspices of the Librarian of Harvard College. It has been prepared by Mr. Samuel H. Scudder, Librarian of the American Academy of Arts and Sciences. The work has double the extent of any existing list of the kind, and aims to include all Society Transactions and independent journals in every branch of natural, mathematical and physical science, excepting only the applied sciences, medicine, agriculture, technology, etc. The arrangement is based on the countries and places where published. It will be a work of great value to all libraries and men of science. The volume will be in octavo, and extend to about 300 pages. Those desiring the work should address Justin Winsor, Librarian of Harvard College, Cambridge, Mass.

4. *Principles of Machine Construction: an application of geometrical drawing for the representation of Machinery;* by EDWARD TOMKINS, edited by HENRY EVERS, LL.D. Vol. i, Text, 368 pp. 8vo; vol. ii, Plates, small quarto. New York, 1878. (G. P. Putnam's Sons—Putnam's Advance Science Series.)—A clearly written and well arranged treatise, rendered the more useful by the numerous illustrations in the text, and still more by the forty-seven excellent plates.

5. *Geological Survey of Victoria.*—Decade 5 of the Paleontology of Victoria, by FREDERICK MCCOY, has appeared. Among the Victorian species mentioned is the graptolite, *Didymograptus Headi*, described by Hall from the Lower Silurian of Canada.

6. *On the Paleozoic fossils of New South Wales;* by L. G. DE KONINCK. 374 pp. 8vo, with an Atlas of 24 quarto plates.—This work is a complete review of the facts relating to the Paleozoic fossils of New South Wales, and contains descriptions of 176 species. Besides this, it enumerates 76 species described by others, of which the writer had not yet seen specimens. Out of the 176, 74 exist also in European rocks.

7. *Mineralogische und petrographische Mittheilungen, herausgegeben* von G. TSCHERMAK; Neue Folge, Bd. I, Heft 1. Vienna, 1878.—The *Mineralogische Mittheilungen* of Vienna, begun by Professor Tschermak in 1872 and published as a supplement to the Jahrbuch of the k. k. Geologische Reichsanstalt have been discontinued. In its place, the Journal, whose title is given above, is to appear independently, in six numbers each year. The new "Mittheilungen" are to be still under the able editorship of Professor Tschermak, and will doubtless take even a more important place among the publications in this branch than the earlier journal. The first number contains five excellent articles upon various mineralogical and lithological subjects.

8. *Marine Zoological Laboratories for instruction of Students.*—A marine laboratory for zoological instruction is to be opened at Fort Wool, on the Rip Raps, near Fortress Monroe, near the

mouth of Chesapeake Bay, under the auspices of the Johns Hopkins University, and the charge of Professor Brooks; and another on Salem Neck, between Beverly and Salem Harbor, Massachusetts, by J. H. Emerton and C. S. Minot, between June 1 and October 1, with the terms $20.00 a month.

9. *Microscopical Society of San Francisco.*—A bulletin from this Society announces that the secretary, Mr. Clarke, will exchange specimens from the diatom deposits of the Pacific Coast on receipt of "any valuable microscopic material."

10. *Earthquake of the South American Coast felt at the Russian Observatory at Pulkowa.*—In a communication to the Academy of Sciences, St. Petersburg, Mr. Magnus Nyrén of the observatory at Pulkowa states that the great earthquake on the coast of South America, in May of last year, was perceptible at Pulkowa by a tremor of the instrument with which he was observing the passage of a star; that the tremor continued sufficiently long to be satisfactorily verified, and that there was no disturbance in the neighborhood by which it could have been occasioned. —*Athenæum*, May 25*th*.

11. *Probable Distribution of a Spider by the Trade Winds.*—Rev. H. C. McCook states that the *Sarotes venatorius* Linn., a large laterigrade spider of the ballooning kind, occurs, according to specimens in his private collection, from Santa Cruz, Virgin Isles, to Cuba, Florida and Yucatan, Central America, Mexico and California, Sandwich Islands, Loochoo Islands and Japan, and thence across Asia and Africa to Liberia, and suggests, in view of these facts and other localities on record, that the trade winds have promoted this distribution. Among the other localities, are the Society Islands, Feejees, Friendly Islands, New Caledonia, Eastern Australia, Mauritius, Madagascar, and several parts of South America. He refers to a fact stated by Darwin, that, at a distance of sixty miles from land, while the Beagle was sailing before a steady light breeze, the rigging was covered with vast numbers of small spiders with their webs, each, when first coming in contact with the rigging, seated upon a single filament of spider web, and so slenderly in some cases that a single breath of air was found to bear them out of sight. Mr. McCook states that the specimens examined by him show *no variations* which may not be accounted for "by differences in age, or which may not come within those ordinary natural differences which all animals more or less exhibit." But most of the specimens had lost their colors in the alcohol in which they were preserved.—*Proc. Acad. Nat. Sci. Philad.*, 1878, p. 136.

12. *Polymicroscope.*—A new improvement in the microscope is reported from Germany. Herr I. von Lenhossék has constructed an apparatus which permits no less than sixty microscopical preparations being observed in immediate succession, without the trouble of changing the slides and readjustment of the object-glass. Its construction is similar in principle to that of the well-known revolving stereoscopes, and the inventor has given the new apparatus the name of "polymicroscope."—*Nature*, June 6.

13. *The Telephone for Deaf Persons.*—Having seen a paragraph in Nature communicated by Mr. Severn, of Newcastle, New South Wales, describing a method of using a telephone to enable deaf persons to hear, I have tried the experiment in the manner Mr. Severn describes—by fastening a string to the parchment diaphragm of a simple telephone made of wood, and carrying this string round the forehead of the deaf person, who clasps the string with both hands and presses them over his ears. The experiment in this way was partially successful; the sound of the voice was always heard, and some words were distinguished. Afterwards I fastened a single string to the telephone and got the deaf person to hold the string between his teeth. He then heard every word distinctly, even when spoken in a low tone of voice at the whole length of the room.—*John Browning, in Nature of June* 13.

New works in Science, notices of which are unavoidably deferred.

Report on Astronomy and Barometric Hypsometry, making vol. II, of quarto Reports of the U. S. Geographical Survey West of the 100th Meridian, under Lieut. G. M. Wheeler. 566 pp. 4to, with 22 plates.

Pennsylvania Geological Survey. Report of Progress in the Beaver River District of the Bituminous Coal-fields of Western Pennsylvania: by J. C. White. 338 pp. 8vo, with 12 plates. Harrisburg. 1878.

Mineralogy and Lithology of New Hampshire, by G. W. Hawes, Geological Survey of New Hampshire. 262 pp. roy. 8vo. With 12 plates. Concord, N. H. 1878.

Report on Food-fishes, Fish-culture for 1875–1876. By S. F. Baird. 1030 pp. 8vo. U. S. Commission of Fish and Fisheries. Washington. 1878.

Report on Geological Survey of Canada, for 1876–77. A. R. C. Selwyn, Director. 532 pp. 8vo. 1878.

Report on Forrestry, prepared under direction of the Commissioner of Agriculture. By F. B. Hough. 650 pp. 8vo. Washington. 1878.

The Speaking Telephone, Talking Phonograph and other Novelties, by G. B. Prescott. 432 pp. 8vo, with many illustrations. New York. 1878. (D. Appleton & Co.)

Annual Record of Science and Industry for 1877, edited by Spencer F. Baird, with the assistance of men of science. 480 pp. New York. 1878. (Harper & Brothers.)

Elements of Dynamic; an Introduction to the Study of Motion and Rest in Solid and Fluid Bodies, by W. K. Clifford, F.R.S. Part I, Kinematic. 222 pp. 12mo. London. 1878. (Macmillan & Co.)

Die Vereinigten Staaten von Nord America, von Dr. Friedr. Ratzel, Professor der Erdkunde zu München. Erster Band, Physikalische Geographie und Naturcharakter. 668 pp. large 8vo, with illustrations. Munich. 1878.

Metasomatic Development of the Copper-bearing Rocks of Lake Superior, by R. Pumpelly. 310 pp. 8vo. Proc. Am. Acad., vol. xiii.

Bulletin of the Bussey Institution of Harvard University. Vol. ii, Part iii. Boston. 1878.

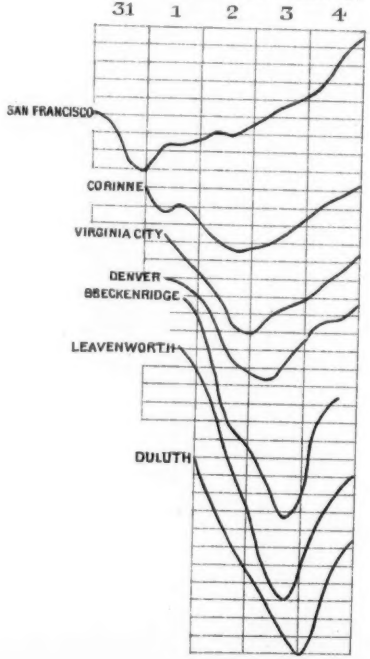
Tafeln zur Bestimmung der Mineralien von Franz von Kobell. Elfte vermehrte Auflage. 110 pp. 8vo. München. 1878.

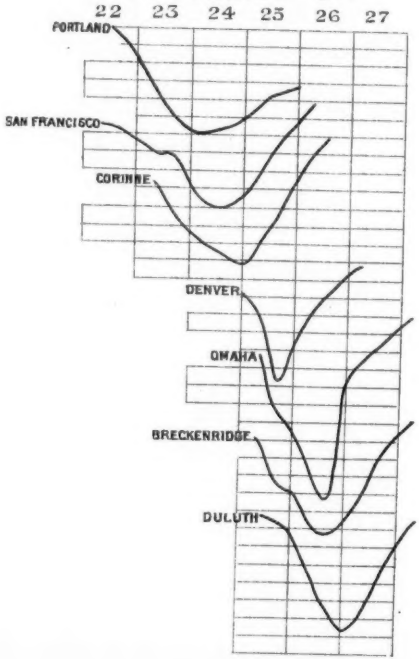
Notes from the Chemical Laboratory of the Johns Hopkins University. Nos. 9–12. Baltimore, Md.

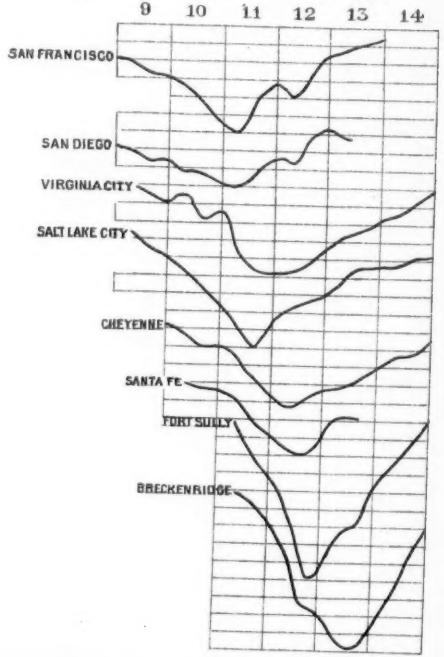
Report on the Hydroida collected during the Exploration of the Gulf Stream by L. F. de Pourtalès, Assistant U. S. Coast Survey and forming No. 2 of vol. v of the Memoirs of the Museum of Comparative Zoology at Harvard College, by G. J. Allman. 64 pp. 4to, with 34 plates. Cambridge, Mass. 1877.

BAROMETRIC FLUCTUATIONS.

PLATE I

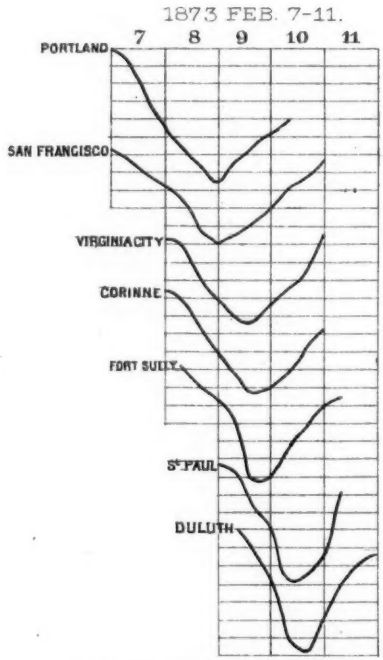


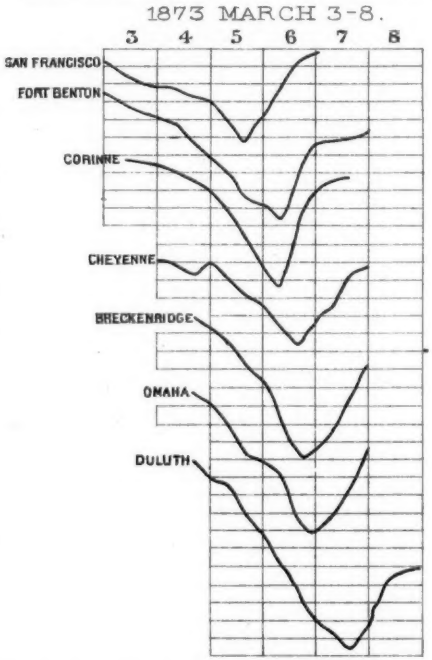


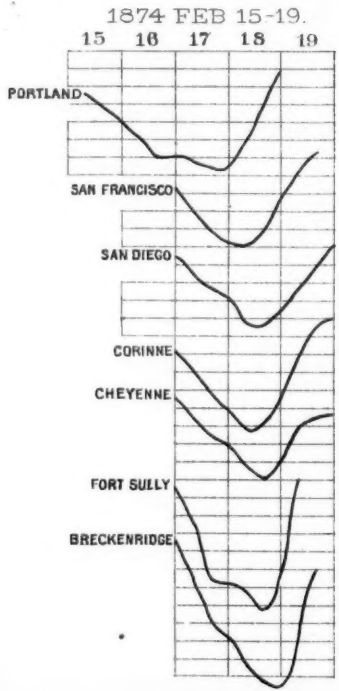


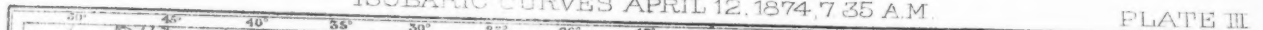
BAROMETRIC FLUCTUATIONS.

PLATE II.








ISOBARIC CURVES APRIL 12, 1874, 7 35 A.M.
PLATE III.

ISOBARIC CURVES APRIL 12, 1874, 7 35 A.M.

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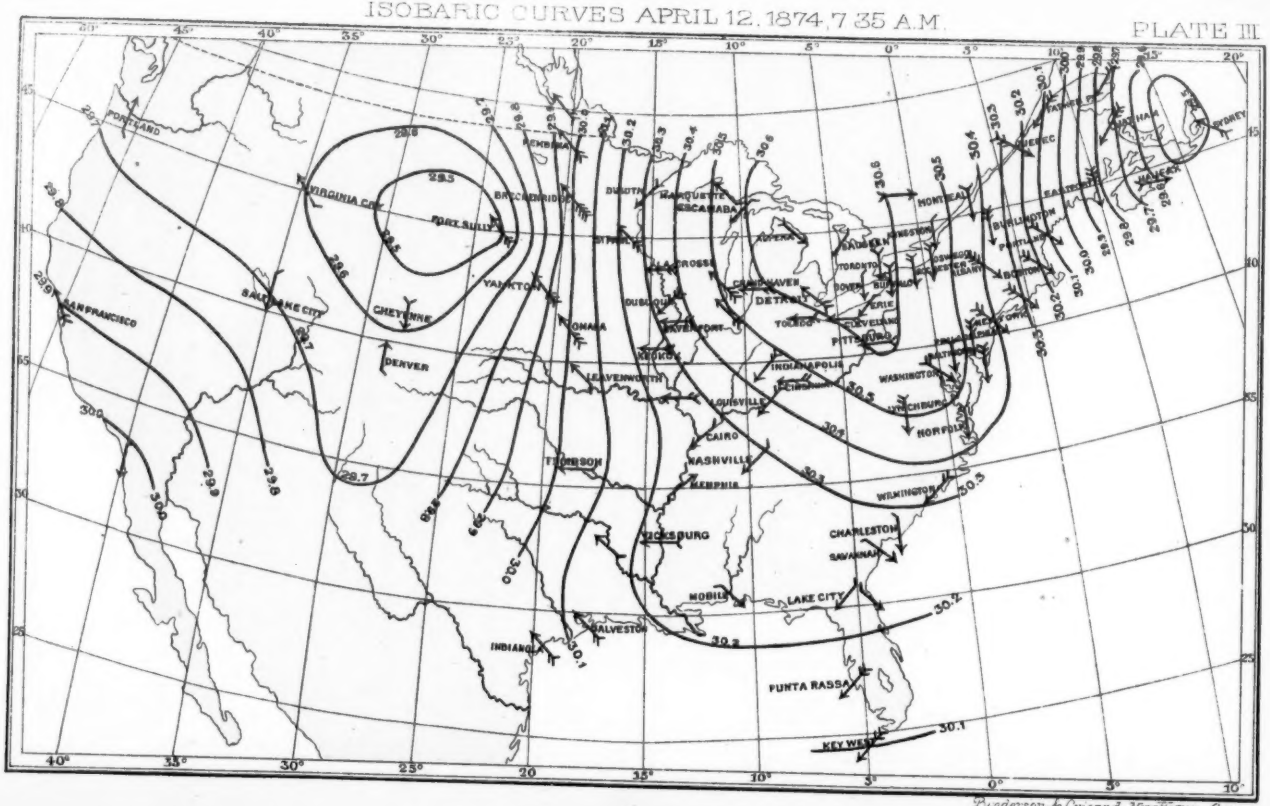

Punderson & Crisard, New Haven, Conn.